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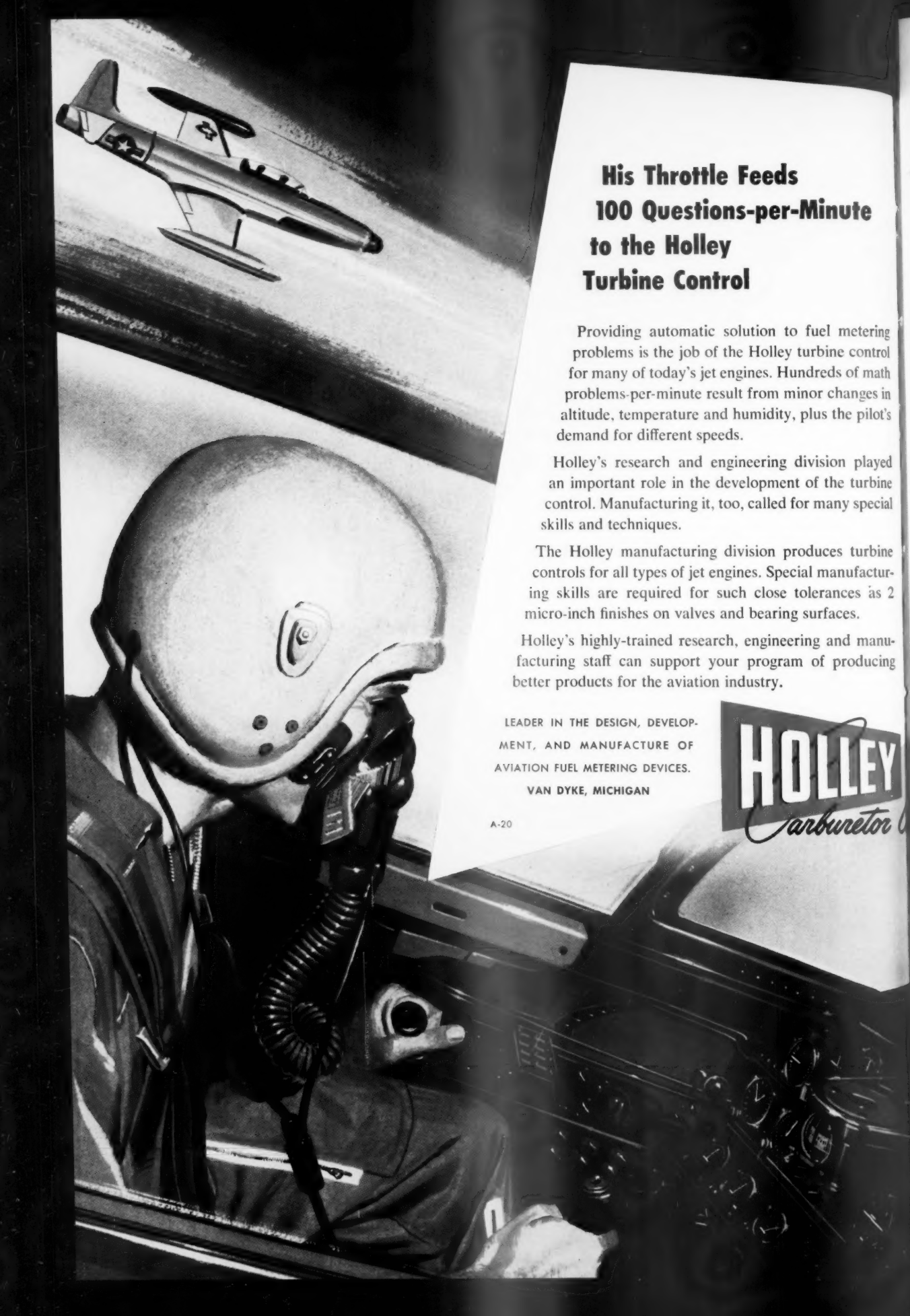
Aeronautical Engineering REVIEW

NOVEMBER, 1954



His Throttle Feeds 100 Questions-per-Minute to the Holley Turbine Control

Providing automatic solution to fuel metering problems is the job of the Holley turbine control for many of today's jet engines. Hundreds of math problems-per-minute result from minor changes in altitude, temperature and humidity, plus the pilot's demand for different speeds.

Holley's research and engineering division played an important role in the development of the turbine control. Manufacturing it, too, called for many special skills and techniques.

The Holley manufacturing division produces turbine controls for all types of jet engines. Special manufacturing skills are required for such close tolerances as 2 micro-inch finishes on valves and bearing surfaces.

Holley's highly-trained research, engineering and manufacturing staff can support your program of producing better products for the aviation industry.

LEADER IN THE DESIGN, DEVELOPMENT, AND MANUFACTURE OF AVIATION FUEL METERING DEVICES.

VAN DYKE, MICHIGAN

A-20

HOLLEY carburetor

Aeronautical Engineering Review

Vol. 13—No. 11 November, 1954

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Cover—The USAF C-123B Avitruc, an assault transport built by Fairchild Aircraft Division of Fairchild Engine and Airplane Corporation, made its first flight on September 1, at which time this picture was taken. With a maximum gross weight of over 50,000 lbs. at take-off, the C-123B can carry a 16,000-lb. pay load in its 3,400 cu.ft. of cargo space a distance of 850 statute miles. It has a 110-ft. wing span, an overall length of 76 ft., and a height of 34 ft. The C-123B is powered by two R-2800 piston engines, manufactured by Pratt & Whitney Aircraft Division of United Aircraft Corporation.

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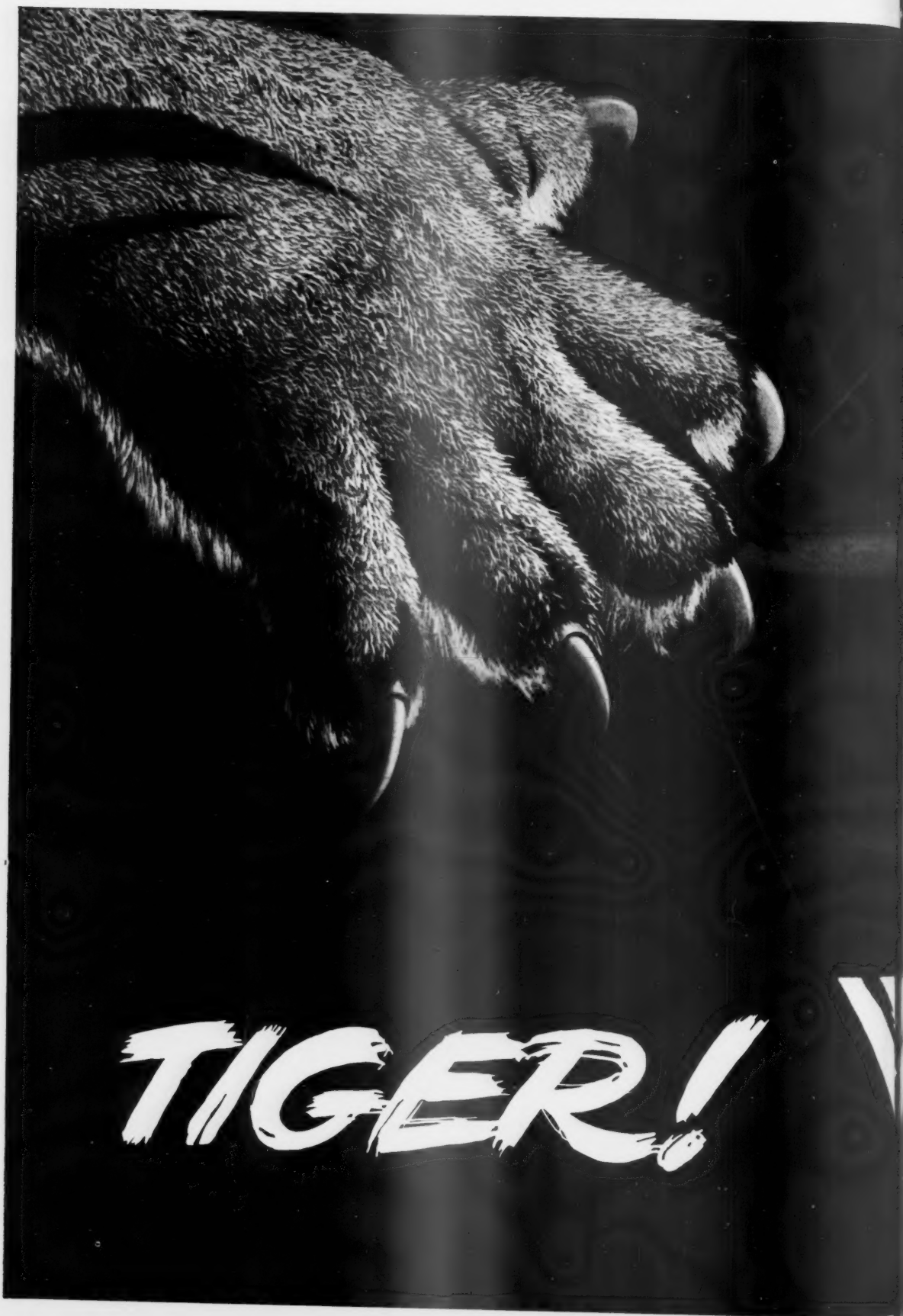

TIGER!

I.A.S. News Notes

November 1954

IAS DIRECTOR AT AGARD MEETING IN PARIS

The Institute of the Aeronautical Sciences was invited to have an observer attend the November meeting of NATO's Advisory Group for Aeronautics (AGARD) in Paris, France. S. Paul Johnston, Director of the Institute, left for Europe via MATS on October 26 to be present at the AGARD panel meetings scheduled for the week of November 1.

On October 28-30, Mr. Johnston met in London with the officers and Council members of the Royal Aeronautical Society and discussed general policies and program planning for the Fifth International Aeronautical Conference. (See National Meetings Calendar below). In order to facilitate the coordination of plans for this Conference, Robert R. Dexter, IAS Secretary, flew to the West Coast on October 20 to discuss Conference arrangements with Los Angles Section officers and Program Committee members.

* * * * * * * * *

FOURTH INTERNATIONAL CONFERENCE PROCEEDINGS AVAILABLE

Proceedings of the Fourth International Aeronautical Conference, published by the Royal Aeronautical Society, are now available. This Conference, a joint RAeS-IAS meeting, was held in London, England, from September 7 to 22.

Copies of this volume may be obtained by writing directly to the Royal Aeronautical Society, 4 Hamilton Place, London, W.1, England. The price per copy is $14.70 (£5.5.0d), and remittance must accompany order. It is understood that a 10% customs duty, imposed by the United States, will be collectable at the time of delivery in this country.

* * * * * * * * *

NATIONAL MEETINGS CALENDAR

Dec. 17	Eighteenth Wright Brothers Lecture, U. S. Chamber of Commerce Bldg. Auditorium, Washington, D. C. Bo Lundberg, Director, Aero. Research Institute of Sweden, Lecturer.
Dec. 20	Eighteenth Wright Brothers Lecture (Repeated), Los Angeles.
Dec. 22	Eighteenth Wright Brothers Lectures (Repeated), Cleveland
Jan. 24-28	Twenty-Third Annual Meeting and Honors Night Dinner, Hotel Astor, New York,
Mar. 11	National Flight Propulsion Meeting (Restricted), Hotel Carter, Cleveland, Ohio.
June 21-24	Fifth International Aeronautical Conference, IAS Building, 7660 Beverly Blvd., Los Angeles, California

* * * * * * * * *

I.A.S. News Notes (con't.)

NECROLOGY

Eugene Gerhardt, TMIAS, Designer, Chance Vought Aircraft, Incorporated, September 11.

* * * * * * *

CALENDAR OF SECTION MEETINGS

Nov. 3-- Chicago Section: Headquarters, Air Line Pilots Association. Meeting, 8:00 p.m. "Flight Control Systems Development" by A. F. Haiduck, Lear, Incorporated.

Nov. 3-- Philadelphia Section: The Franklin Institute. Dinner, 7:00 p.m.; Meeting, 8:00 p.m. Speaker - Ivan H. Driggs, Chief Scientist, Naval Air Development Center, Johnsville, Pa.

Nov. 6-- Los Angeles Section: Field trip to California Institute of Technology, beginning at 10:30 a.m. Inspection tour of the hypersonic wind tunnel facility and Hydrodynamics Laboratory.

Nov. 6-- San Diego Section: IAS Building. Annual Fall Dance, 9:00 p.m. to 1:00 a.m.

Nov. 16-- Dayton Section: Cordell's Supper Club, Fairborn, Ohio. "Aerobee Sounding Rocket" by Alfred B. Longyear, Aerojet-General Corporation.

Nov. 16-- Hampton Roads Section: Projection Room of NACA Administration Building. Meeting, 7:30 p.m. "Naval Aviation Research and Development" by Capt. J. N. Murphy, USN, former Executive Director, Research and Development Group, BuAer, U. S. Navy. Social hour to follow.

Nov. 17-- Seattle Section: Sand Point Naval Officer's Club. Meeting, 6:00 p.m. "Report on Boeing Model 707" by D. W. Finley, Joe Sutter, and R. L. Bell.

Nov. 18-- Los Angeles Section: IAS Building. Social hour, 6:00 p.m.; Dinner, 7:00 p.m.; Meeting, 8:15 p.m. "Bases Unlimited" by E. G. Stout, Chief, Naval Aircraft Research, Convair Division of General Dynamics Corporation.

Nov. 18-- New York Section: Sperry Gyroscope Company. Dinner meeting, 6:30 p.m. "Product Planning and Engineering's Role in its Implementation" by Edward Woll, Manager of Engineering, Small Aircraft Engine Department, General Electric Company.

Nov. 19-- Washington Section: Museum of Natural History Auditorium. Meeting, 8:00 p.m. "The International Geophysical Year" by Dr. Joseph Kaplan.

Dec. 9-- Dayton Section: Plant tour of Aeroproducts Operations of Allison Division, General Motors Corporation, Vandalia, Ohio. Tour to begin at 6:30 p.m.

* * * * * * *

IAS News

A Record of People and Events of Interest to Institute Members

Swedish Engineer to Present Eighteenth Wright Brothers Lecture

Bo Lundberg, Designer of Swedish J-22 Fighter, Selected as Wright Brothers Lecturer

Bo Lundberg

BO K. O. LUNDBERG, Director of the Aeronautical Research Institute of Sweden (Flygtekniska Försöksanstalten), Stockholm, Sweden, will deliver the Eighteenth Wright Brothers Lecture on December 17 in the U.S. Chamber of Commerce Building Auditorium, Washington, D.C. His subject will be "The Fatigue Life of Airplane Structures."

A summary of Mr. Lundberg's talk is as follows:

"The dominating difficulty in the increasingly important problem of fatigue in airplane structures is the very great scatter that is typical for all its main aspects. Due to the fact that this scatter to a large extent is of an inherent nature and thus cannot be eliminated, it will never be possible to predict the fatigue lifetime for an individual airplane with reasonable accuracy—i.e., an error of several hundred per cent will probably always be present.

"Consequently, our efforts should be concerned not with the prediction of fatigue life but with the prevention of fatal fatigue failures down to an extremely low failure rate. A result of this general philosophy is the conception of a 'limit' fatigue life defined as the life, in miles or hours flown, up to a 'limit' probability level for fatigue failure. The combination of the limit life and its corresponding limit probability level should be such that the failure rate resulting from this combination has a satisfyingly low level, which if possible should be agreed upon internationally.

"With these general thoughts as a background, the paper presents a survey of the various aspects of the fatigue of complete airplane structures together with numerical application. The survey is to some extent supported by test results obtained in Sweden. A general formula has been developed for the calculation of the cumulative damage. This formula has been used for the preparation of some charts for the calculation of the limit life as a function of the most important design and fatigue parameters. A new method by Weibull for the determination of S-N curves at various probability levels is discussed and applied.

"Finally, it is emphasized that due to our highly insufficient knowledge of the very complex problem of fatigue in aeronautics the survey presented has the nature more of a frame of the problem than of a complete picture."

Mr. Lundberg, FIAS, FRAeS, received his flight training with the Royal Swedish Air Force in 1926. He was graduated in 1931 from Sweden's Royal Institute of Technology. That same year, he joined the Airplane Division of Swedish Railway Works, Inc., as Chief of Aerodynamics and Structures and Test Pilot. In 1935, he became Test Pilot and Chief, Department of Calculations, for E. Sparmann's Airplane Works. He occupied the post of Assistant Chief Inspector, Royal Board of Civil Aviation, in 1937 and 1938. During 1939, he was Chief of A. B. Götaverken's Aircraft Division. He spent the following year in the United States as a member of the Royal Swedish Air Force Commission. [Mr. Lundberg, an RSAF Reserve officer since the 1920's, was promoted to Captain in 1940 and to Major (Technical) in 1944.]

Prior to World War II, Sweden had procured the vast majority of its aircraft either by importing them or by building foreign ones under license. With the advent of World War II, Sweden decided to develop its own aviation industry that would manufacture planes of its own design. The RSAF aircraft plant in Stockholm that resulted from this new policy was organized about 1941 by Mr. Lundberg, and, in his capacity as Chief Designer, he was responsible for the design of the J-22, an all-Swedish fighter that subsequently was in common use in the Swedish Air Force. Because the need at that time to build up a strong air defense was of prime importance, the J-22 went into quantity production 6 months before the prototype made its first flight. It was reported in 1943 that the first test flights of the prototype disclosed no serious defects or shortcomings, and no major modifications were required.

In 1943, Mr. Lundberg was named Chief of the Design Office of the RSAF's Aircraft Board, where he undertook fundamental and theoretical studies of the application of jet propulsion to aircraft. The following year, he was named Chief of the Structures Department at the Aeronautical Research Institute of Sweden, and, in 1948, he was appointed to his present position as Director of that institution.

A Brief Summary of the

National Turbine-Powered Air Transportation Meeting

Members who were not present in Seattle around August 9–11 missed one of the most successful meetings the Institute has ever held. Timed as it was to coincide with the introduction of America's first jet transport airplane, this single-theme session engendered a degree of interest not often encountered in technical society gatherings anywhere.

Doubtless, Seattle's "Seafare" week and the Gold Cup Races added a note of attraction. But it was the widespread interest in Boeing's "707" and the problems connected with turbine-powered transportation that packed them in at the Ben Franklin Hotel. Over 550 persons—representing practically every segment of the industry and Government in the country—were on hand for the 3-day meeting. Representatives from firms in seven foreign countries also participated.

▸ **Technical Sessions**—The high percentage of attendance at all five technical sessions indicated the importance attached to each and every one of the papers. Under the capable guidance of such session chairmen as S. Scott Hall, Hall L. Hibbard, E. S. Thompson, R. W. Rummel, and E. C. Wells, the following papers stimulated some very worth-while discussions:

The Boeing "707" was the center of attraction as IAS members toured the Boeing plant on August 11.

"Turbine-Powered Transports" by Lt. Gen. Joseph Smith, USAF, Commanding General, Military Air Transport Service.

"Airline Turbine Transport Considerations" by M. G. Beard, Assistant Vice-President, Equipment Development, and F. W. Kolk, Research and Development Engineer, American Airlines, Inc.

"CAA and Turbine-Powered Transportation" by F. B. Lee, Administrator, Civil Aeronautics Administration.

"Long-Range Propeller-Turbine-Engined Transports" by W. J. Strang, Chief Aerodynamicist, Bristol Aeroplane Company, Limited, Aircraft Division.

"Some Design Considerations in the Development of the Douglas Model YC-124B Turbo-Prop Transport" by D. L. Elder, Aerodynamics Group, Long Beach Division, Douglas Aircraft Company, Inc.

"Design Considerations of the Boeing Model 707" by M. L. Pennell, Chief Project Engineer, Boeing Airplane Company.

"Turbo-Propeller Engine Application to Transport Aircraft," by Philip A. Colman, Chief, Preliminary Design, Lockheed Aircraft Corporation.

"Some Performance Considerations of a Jet Transport Airplane" by G. S. Schairer, Chief of Technical Staff, and M. Lynn Olason, Aerodynamics Unit, Boeing Airplane Company.

"Operational Characteristics of Turbo-Prop Propellers" by G. W. Brady, Director of Engineering, Propeller Division, Curtiss-Wright Corporation.

"Stopping Large Jet Airplanes" by J. E. Steiner, Project Engineer, Preliminary Design, Boeing Airplane Company.

"Turbine Engines for Transport Airplanes" by Abe Silverstein, Associate Director, and Bruce T. Lundin, Chief, Engine Research Division, Lewis Flight Propulsion Laboratory, NACA.

Much of the success of the first National Turbine-Powered Air Transportation Meeting is directly attributable to the planning and hard work of these various committee chairmen. *Seated left to right:* Elaine Gething, Registration; G. W. Taylor, Chairman, Arrangements Committee; Fred Maxam, Treasurer; Harry Carter, Secretary; and Bob Hage, Dinner and Lunch Arrangements. *Standing, left to right:* Lloyd Goodmanson, Plant and Airplane Inspection Tours; R. D. Fitzsimmons, Housing; Norm Bennett, Meeting Space; Don Schelp, Facilities and Equipment; Mark Kirchner, Transportation and Hospitality; and Bob Joppa, Publicity and Information.

"Selection of Fuels for Commercial Turbine-Powered Aircraft" by C. R. Johnson, E. R. Kennedy, and W. S. Little, Shell Oil Company.

"Waterbasing the Jet Transport" by Marvin I. Haar, Chief, Water-Based Aircraft Division, Experimental Towing Tank, Stevens Institute of Technology.

"Jet Streams and Project Skyfire" by Vincent J. Schaefer, The Munitalp Foundation.

Although these titles would seem to indicate a wide field of diversified activities, every paper had a direct bearing on the main subject in which everyone was interested. This common interest and the interrelationship of the papers accounted for five highly successful sessions.

▸ **Proceedings**—This interrelationship of subjects also accounts for the Institute's decision to publish a single volume of Proceedings. Individually, these papers represent only one interesting part of the story. Collectively, they shed a lot of light on the problems and possibilities connected with jet transports and turbine-powered air transportation of the future.

Copies of the Proceedings, containing all of the complete papers, are now available through the IAS Preprint Department. (Price, $3.50 to members; $6.00 to nommembers.)

▸ **Dinner**—The dinner program on the evening of August 10 featured a word of welcome from Boeing's President, William M. Allen, and a principal address by United Aircraft's Leonard S. Hobbs. (Excerpts of the latter appeared as a Guest Editorial in the October REVIEW and are also contained in the volume of Proceedings.)

No empty chairs were to be found in the hotel ballroom's 400-plus seating capacity during any of the technical sessions.

In welcoming IAS members to their first national meeting in Seattle, Mr. Allen re-emphasized Boeing's faith in the future of jet transportation. He also voiced the conviction that the importance of this subject and the enthusiasm engendered at this first meeting dictated the wisdom of holding a "repeat performance" in Seattle next year. (Consideration is already being given to another meeting in Seattle next August—ED.)

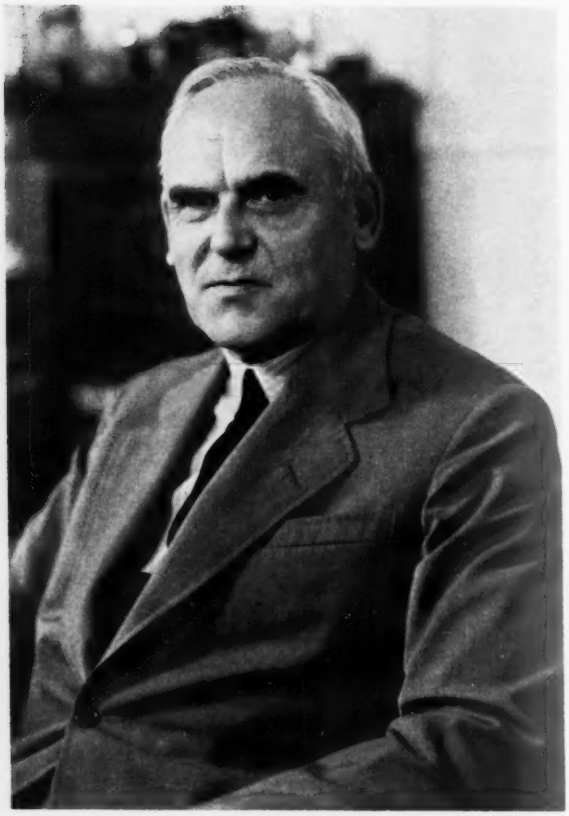
IAS President Lee Atwood was on hand to introduce the speakers and guests and to serve as toastmaster for the occasion.

▸ **Boeing Plant Tour**—A fitting and natural climax to the 3-day meeting was the viewing of America's first jet transport. As guests of Boeing Airplane Company, the entire group was treated to a tour of the plant, luncheon in the company's cafeteria, a flight-demonstration of a B-47, and an impressive static display of the Giant "707" and other recent Boeing developments.

All in all, it was a fine show and an enlightening meeting. Members of the IAS Seattle Section who planned the program and carried out the details deserve the highest praise and congratulations. A debt of gratitude is also owed the officers and staff of the Boeing company for their cooperation and hospitality. W.A.S.

Principals at the Seattle dinner included *(left)* William Allen, President of Boeing Airplane Company; *(center)* Leonard S. Hobbs, who gave the formal dinner address; and Toastmaster Lee Atwood, President of North American Aviation, Inc., and 1954 President of the IAS.

1954 Guggenheim Medalist



The Right Honorable Clarence Decatur Howe

For "initiating and organizing commercial air routes and services, promoting aeronautical research, development and production of aircraft and engines, and advancing the art of aeronautics."

The Right Honorable Clarence Decatur Howe, Minister of Trade and Commerce and Minister of Defense Production, Canada, was awarded the Daniel Guggenheim Medal for 1954. Mr. Howe was cited for "initiating and organizing commercial air routes and services, promoting aeronautical research, development and production of aircraft and engines, and advancing the art of aeronautics." The presentation was made at last month's National Aeronautic Meeting of the Society of Automotive Engineers.

A native of Waltham, Mass., Mr. Howe was graduated in 1907 from Massachusetts Institute of Technology. After 6 years in the academic field, he became Chief Engineer, Board of Grain Commissioners for Canada. In 1916, he formed C. D. Howe & Company, specializing in the design and construction of terminal grain elevators.

In 1935, he was appointed Minister of Railways and Canals and Minister of Marine. When these posts were consolidated in 1936, he became Minister of Transportation. Four years later, he was made Minister of Munitions and Supply, with the portfolio of Reconstruction being added in 1944. In 1946, he assumed the duties of Minister of Reconstruction and Supply.

Among the things accomplished during Mr. Howe's tenure as Minister of Transportation were the organization of operating and ground services for the first Canadian transcontinental air system and the founding of Trans-Canada Air Lines. As Minister of Munitions and Supply, he supervised the growth of Canada's aircraft industry from 200 to 4,000 planes per year. As Minister of Reconstruction, he saw that government-owned companies were turned over to private interests. As Minister of Trade and Commerce, he is currently Chairman of the Privy Council on Scientific and Industrial Research, which has the responsibility for a variety of government aeronautical laboratories.

The Guggenheim Medal is presented annually by the American Society of Mechanical Engineers, Institute of the Aeronautical Sciences, or the SAE. Each of these organizations awards it every third year.

American Non-Gran Becomes IAS Corporate Member

The American Non-Gran Bronze Company has joined the Institute of the Aeronautical Sciences as a Corporate Member. The firm is located in Berwyn, Pa.

American Non-Gran Bronze Company was founded in 1907 as a sand-casting foundry. Its main product has been a bronze alloy, known as Non-Gran. This alloy, the company says, gives an unusually long-wear life because of its composition of virgin metals only and because of a special melting process.

During World War I, the aircraft industry became one of the large users of this alloy and applied it to the Liberty engine. The Navy-Curtiss NC-4 flying boat and the Ryan-built "Spirit of St. Louis," which made west-east crossings of the Atlantic in 1919 and 1927, respectively, carried bearings and bushings formed from this alloy.

This Berwyn, Pa., company has supplied the Pratt & Whitney Aircraft and Hamilton Standard divisions of United Aircraft Corporation since their organization. During World War II, parts were supplied to most of the aircraft engine manufacturers, as well as to the many licensees. Following this period, there was a diversification of products to meet the demands of industry.

AMS National Meeting

The One Hundred and Thirty-Third National Meeting of the American Meteorological Society will be held at the Empress Hotel, Miami Beach, Fla., on November 17–19, 1954.

The technical sessions will be highlighted by a Panel Discussion on Tornado Research, sponsored by the U.S. Weather Bureau. Participating in this discussion will be representatives from the U.S. Air Force, U.S. Navy, and various universities and civilian organizations that are conducting research on tornadoes. Other technical sessions will include topics of Radar Aids to Meteorology and Tropical Meteorology.

IAS members who plan to attend this meeting should make reservations directly with the Empress Hotel, 4333 Collins Ave., Miami Beach.

S.L.A. Translation Supplement Available

A supplementary list of translations received in the Special Libraries Association Translation Pool is now available from the John Crerar Library. This supplement to the "S.L.A. List of Translations, October, 1953" lists nearly 700 titles received in the Pool since October, 1953. It can be ordered at $1.00 a copy, with payment in advance, from: Special Libraries Association Translation Pool, John Crerar Library, 86 E. Randolph St., Chicago 1, Ill.

Under contract with the Special Libraries Association, the John Crerar Library now maintains and services the Translation Pool. At the present time, approximately 2,000 translations from all languages except Russian are on file.

Necrology

Thomas P. Buckley

Thomas Patrick Buckley, TMIAS, Sales and Field Engineer, Air Appliance Division, U.S. Hoffman Machinery Corporation, was killed in an airplane accident at Elmira, N.Y., on July 4.

Mr. Buckley was born in New York City on June 25, 1928. He attended the Cardinal Hayes High School in New York and later the Academy of Aeronautics. He was graduated from the latter school in August of 1950.

His first job was with the Sikorsky Aircraft Division, United Aircraft Corporation, as Field Service School Instructor and as Weights Engineer. He then became Stress Analyst for Republic Aviation Corporation. After a time at Republic, he left to join Simmonds Aerocessories, Inc., as Applications Engineer in the company's Sales Department. He became associated with U.S. Hoffman Machinery Corporation in July of 1953.

Mr. Buckley is survived by his mother, Mrs. Mary Buckley.

Ralph N. DuBois

Ralph Nicholas DuBois, IAS Associate Fellow and Council Member, Chief Product Engineer, Aircraft Engine Division, Ford Motor Company, was stricken fatally on August 15 while horseback riding. Death is believed to have been caused by a heart attack.

Born in Washington, D.C., on May 3, 1898, Mr. DuBois attended the District's Technical High School and later matriculated at the University of Michigan, where he majored in aircraft-engine design. He was granted his B.S.E. degree in Mechanical Engineering in 1922.

From 1922 to 1927, he was with the National Bureau of Standards as Associate Mechanical Engineer. He became a Research Engineer with General Motors Corporation's A.C. Spark Plug Division in 1927 and 2 years later left there to accept the position as Assistant Chief Engineer, Aircraft Division, Continental Motors Corporation.

In 1934, Mr. DuBois joined Aviation Manufacturing Corporation as Project Engineer and in 1940 joined Packard Motor Car Company's Aircraft Engine Division as Executive Engineer. After several years with Packard, he went to South America where he was Professor-in-Charge, Department of Power Plants, Technical Institute of Aeronautics of Brazil. He returned to this country in 1951 and began his association with Ford Motor Company.

Mr. DuBois is survived by his widow, Mrs. Helen DuBois, and a daughter, Mary.

Henry P. Folland

Henry Phillip Folland, an IAS Fellow and Founder Member, died on September 5 at Nottingham, England. Mr. Folland was 65 years old.

In his youth, he was apprenticed to Lanchester Motor Company as a member of the design staff, Swift Motor Company, and Daimler Motor Company, Ltd. In 1912, he became an Assistant Designer for the Royal Aircraft Establishment and for the next 5 years was responsible for carrying out the designs of the F.E.2B, S.E.4, S.E.5, etc. In 1917, he joined British Nieuport Company, Ltd., as Chief Engineer and Designer and designed such aircraft as the Nieuport Nighthawk and Nieuport London, the latter being a twin-engined bomber triplane.

In 1921, Mr. Folland began a long association with Gloster Aircraft Company, Ltd. He served first as Chief Engineer and Designer and later as Chief Designer and Technical Director. He designed the Bamel racing aircraft that won the Aerial Derby in 1921, 1922, and 1923, and the Schneider Trophy racing planes, Gloster 3, 4, and 5. He was also responsible for the design of a long line of Gloster aircraft, e.g., Grebe, Gamecock, Gauntlet, Gladiator, etc. Three Gladiators, named "Faith," "Hope," and "Charity," held off a World War II seige at the island of Malta.

Mr. Folland had been a Director of Folland Aircraft, Ltd., since 1937. In the recent SBAC Aircraft Show and Flying Display at Farnborough, England, a jet fighter bearing his name was shown. It was the Folland Midge.

Robert J. Minshall

Robert James Minshall, FIAS, died on September 7 of a cerebral hemorrhage at his home in Shaker Heights, a suburb of Cleveland.

Born in Sutherland, Neb., on August 25, 1898, Mr. Minshall received his B.S. (C.E.) degree *magna cum laude* in 1923 from the University of Washington. In 1915, several months after he had first gone to work as an Aeronautical Mechanic for G. W. Stromer, of Tacoma, Wash., he took flying lessons and did some passenger hopping in the Tacoma area.

He left Stromer in 1918 to begin an association with Boeing Airplane Company which lasted for the next 23 years. He began as a Blueprint Clerk, and when he resigned from Boeing in 1941 he was Vice-President—Engineering. Among Mr. Minshall's achievements during his years at Boeing are: in 1922, he helped design the first flying boat used in International Airmail Service; in 1928, he designed a U.S. Army pursuit ship that was called the

(*Continued on page 70*)

Sixth Annual Air Cargo and Air Logistics Days Program

November 29–December 3 ***Hotel Statler, New York***

The program will be presented during the American Society of Mechanical Engineers Annual Meeting. It will consist of eight sessions: The Role of the Turboprop and Turbojet Transports (including a panel discussion on turboprop versus turbojet); Military Air Transports; Civil and Military Transports; Rotary Wing and Air Cargo Handling; Effects of the Thermal Barrier on Propulsion Systems; Effects of the Thermal Barrier on Equipment and Accessories; Effects of the Thermal Barrier on Aircraft Structures; and Turbojet Components.

The following societies join the ASME in cosponsoring some or all of these eight sessions: Society of Automotive Engineers, National Security Industrial Association, Transport Air Group, American Rocket Society, and Institute of the Aeronautical Sciences.

Readership Survey Statistics

Total Questionnaires Mailed	9,000	Per Cent Returned	36.3
Total Questionnaires Returned	3,265	Total Questionnaires Processed Below	2,860

(1) Which of the three sections of the magazine are of greatest interest to you?

	1st Choice		2nd Choice	
(a) Articles	2,063	72.1%	559	19.5%
(b) Reviews	507	17.7	1,274	44.5
(c) IAS News	277	9.7	840	29.4

(2) Which of the following general subjects are of primary interest to you?

	1st Choice		2nd Choice	
Aerodynamics	842	29.4%	352	12.3%
Accessory Equipment	96	3.3	102	3.6
Aircraft, Commercial	139	4.9	206	7.2
Aircraft, Military	360	12.6	378	13.2
Aircraft, Personal	84	3	103	3.6
Aircraft, Rotary Wing	156	5.5	115	4
Airports	8	0.3	20	0.7
Air Transportation	85	3	67	2.3
Aviation Medicine	15	0.5	25	0.9
Communications	23	0.8	32	1.1
Electronics & Electrical	99	3.5	139	4.9
Fuels & Lubricants	27	0.9	44	1.5
Instruments	85	3	117	4.1
Manufacturing Techniques	116	4.1	158	5.5
Materials	64	2.2	197	7
Meteorology	17	0.5	31	1.1
Missiles	257	9	358	12.5
Navigation	26	0.9	37	1.3
Power Plants & Propulsion	410	14.3	311	11
Propellers	18	0.6	59	2.1
Structures	383	13.4	190	6.6
Wind Tunnels	58	2	223	8

(2a) With what phases of the foregoing subjects are you most concerned?

Administration	702	24.5%
Design	1,899	66.4
Operation	786	27.5
Production	681	23.8
Research	1,768	61.8
Safety	307	10.7
Sales	198	7
Servicing	204	7.1
Testing	1,128	39.4

(3) Do you retain the REVIEW *for further reference?*

Yes	2,147	75.1%
No	634	22.2

(4) Do you pass your copy around for others to read?

Yes	1,563	54.7%
No	1,192	41.7

(5) Do you find the New Products Section of interest or value?

Yes	1,911	66.8%
No	782	27.3

Editorial

Customer Appraisal

One of the best ways to get a reading on the acceptability of any product is to ask the customers how they like it. The makers of cigarettes or breakfast cereals do not have to go through this sort of exercise. They get an almost day-to-day check from their sales invoices and shipping records. It isn't quite so easy for a publication. It takes a relatively long time to get customer reaction. Sheer inertia prevents people from sitting down to write indignant letters to the editor until the situation deteriorates to the point where they simply cancel subscriptions.

The REVIEW gets little benefit from this kind of behavior because it is a part of our regular service to our members. So, from time to time we feel that we should ask them how we are doing. This we must know in order to try to make the magazine of greater use to the greatest number.

Twice in the past 5 years we have sent out questionnaires to all IAS members asking them, by a frank expression of opinion, what they like and dislike about the magazine and how its editors can make it better. In both cases the response has been excellent—and most helpful. If anyone is interested in our Survey Number One, reference can be made to the June, 1949, issue of the REVIEW.

The preliminary figures on the latest referendum are now in. We had over 3,000 returns out of a 9,000 mailing, which is an unusually high average for an editorial survey (commercial publications consider 6–8 per cent excellent). This in itself is a good indication of REVIEW readership. It was obvious, too, from the tone of practically all the replies that much serious thought had been given to them.

Another good indication—some 75 per cent of readers find the REVIEW's content of sufficient importance to be filed for future reference. Fifty-five per cent indicated, too, that they made a point of passing the magazine along to their colleagues for their use. The total number of readers, therefore, not counting the unknown totals who read the REVIEW in company or IAS libraries, is many times greater than the total IAS membership.

The statistics on the opposite page give a pretty clear picture of the readers' preferences. Since Articles were the overwhelming first choice, the changes wrought since the original conception of the REVIEW seem to have established it as a number one magazine with aviation engineers.

Not all the facts, however, are revealed in these figures alone. More than a thousand questionnaires returned contained comments, suggestions—and many constructive criticisms—which show a genuine interest in the progress of the magazine and the Institute.

We cannot express too highly our thanks and appreciation to our readers for the interest they have taken in helping to steer the REVIEW along a more useful course. All suggested changes cannot be made fully and immediately, but what you have told us will provide the editors and editorial committees with invaluable guideposts for the future.

S.P.J.

The Air Weapon Systems in Operation

MAJOR GENERAL CLARENCE S. IRVINE*
Air Materiel Command

Introduction

That the weapons of air warfare are becoming extremely complex I need not remind you. Complexity leads to specialization. When airplanes were basically an air frame and a pretty simple engine, a fairly average man could be an aircraft engineer and a reasonably good authority on the whole airplane. It is not quite so easy anymore—in fact, it comes close to being impossible for one man to be an expert on a modern airplane. Today he would need to be an aircraft designer, an aerodynamicist, a metallurgist, a combustion engineer, an ordnance expert, an electronics wizard, a photobug, and a few more things besides—about what the best of us could easily attain in five or six lifetimes.

Well, specialization in our business has resulted quite naturally in the formation of relatively independent groups, each working on its engineering specialty, and, from the point of view of their primary interest, this is the way to advance most rapidly.

Air Force Objective

The final objective of the Air Force, however, is to achieve a balanced effort, because the complete end item—a weapon system—is no good without any one element. For example, we could have just the right power plant fully developed for use in a missile, but, without a guidance system, we still do not have a missile; or, we can deliver an airplane with the engine, fire control equipment, and all other components working fine, but if we are not at the same time able to deliver the support and test equipment, the airplane cannot be used to perform its mission, and, therefore, we still do not have a weapon system.

Technology in the Past 15 Years

The technologic advances in the last 15 years have been tremendous; probably there has been no period in the history of the world to equal the last 15 years during which we have advanced technologically at a rate far beyond the wildest dreams of the majority of us.

Complications

The machinery and personnel know-how in the Air Force for handling and controlling this spectacular advance has just not kept pace. Patchwork fixes have been applied, but complete control has eluded us. A pattern, however, has been developing; a simplified and effective arrangement is being evolved. Things like this do not just happen overnight in an outfit as big as ours, and it will require time and patience before complete accomplishment of the objective can be realized.

Now I would like to outline for you our principal objectives, and how it is proposed we attain them.

Sequence of Production

(1) In the accumulation of Air Force materiel, a natural sequence of events occurs, as in any business. First comes the idea; then a determination, by experiment and test, of the practicability of the idea; next, the determination to produce, followed by many changes and refinements during the process of production until an acceptable and usable piece of hardware comes rolling off the production line. Now this process has, by fairly universal consent, always been divided into two areas of effort. The first of these two areas is research and development. The second is production.

Actually this word description of the two areas is not entirely adequate because there is some development involved with the research, but there is also development involved with the production. However, the two areas can be described as (a) getting ideas and establishing their practicability, and (b) completing the development of and producing the hardware. The amount of development included in (b) is determined by the state of development when the decision is made to produce. Decision is based on need—set by our competition.

(2) It is a fairly well accepted fact that the most recent world war was won by the Western Allies because of the volume of their equipment rather than its technical excellence. The Germans were found to have been far ahead of us in research and development. General Arnold believed that action was required immediately to correct the situation so that we would not be in the same position should the nation again become involved in war. The Scientific Advisory Board was established, and the Rideñour Report followed.

Research and Development Command

Research and development and production had been the responsibility of one agency in the past, and, quite naturally, during periods of reduced military spending, research and development suffered. It was recognized that one way to obtain proper recognition of the importance of research and development during periods of peace would be to make organizational changes in the Air Force in order that

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(1) The function of research and development would be separated from the logistic function in the Air Staff so that it would receive proper attention and an appropriate share of the funds, and

(2) An appropriate number of properly qualified people in the Air Force would give their entire attention and effort to ensuring that the money obtained was used to keep the Air Force technologically abreast, or ahead, of all other nations in the world. This organizational change was made, and the Deputy Chief of Staff—Research and Development and the Air Research and Development Command were the result. The philosophy was that there were two separate jobs to be done and, therefore, if they were separated, one would not become subordinate to the other to the detriment of the nation's defense. Certainly there was sound reasoning behind this basic concept.

We are still wrestling, however, with the problem of how to obtain the objectives therein defined without splitting up responsibility to a point where complicated procedures and "too many cooks" spoil the broth. All of this took place in a period when there were not nearly enough good engineers to go around and the Air Force was hard put to compete with industry for this talent. The inevitable result, of course, was that the talent available to the Air Force was spread so thin that the quality of decisions resulting in many areas could be improved.

AMC-ARDC Wedding

It has been apparent all along that the conflicting but necessary elements of specialization engineering on the one hand, and coordination and compromise production on a schedule on the other, must be wedded. As in all forced weddings, there have been, and still are, a few problems; unfortunately, they are tough problems.

Recognizing industry's need to have a single point of contact with the agency with whom they contract in order that they may get answers and decisions expeditiously, ARDC and AMC got together and formed joint project offices and supporting weapons phasing groups to include supply, maintenance, and our Air Force customers. We have recently renamed them weapons systems offices. A further step was decentralization, the principal objective of which was to get the maintenance, supply, procurement, and funding representatives for a particular product—such as an aircraft series—under one boss, the Prime Depot Commander, and if possible under one roof. When production has been completed, or well along, we shall delegate the whole product package to the depot.

Concepts of Weapon Systems

Design, logistics, maintenance, people, service, training, and many other aspects are all a part of a weapons system.

I would like to take some of the mystery out of the business and give you an idea of what we are trying to do.

Since World War II, due to the exceptionally rapid advance in the aeronautical sciences, we have emphasized the design and performance of aircraft or air frames. But, as armament and ordnance have progressed beyond the stage of the 30-cal. bullet and the TNT bomb, the question of how fast and how high the aircraft will fly has turned out to be only a beginning. New armament systems, autopilots, electric fuel controls, electric countermeasures, and reconnaissance systems have complicated the picture—not to mention the fact that we are always trying to put 50 gal. of fuel in a 25-gal. space. With the increased speeds and altitudes of aircraft, however, the complex electronic "thinking" apparatus of aircraft becomes a "must" instead of an optional extra.

Complex Equipment Essential

Much has been said about the complexity barrier of the electronic and electromechanical devices used in modern aircraft. These take their place alongside the human engineering and metallurgy problems, and all must be solved.

The weapon systems project offices and their supporting weapons phasing groups were established for the purpose of attacking these problems from the design, production, maintenance, supply, and funding aspects. This attack must be started in the design stage.

In order to achieve all of the high-performance capabilities during design and, at the same time, incorporate all of the new complex devices, the Weapon System Project Office (formerly known as the Joint Project Office) was established. This weapon systems management office consists of a combined ARDC engineering and AMC procurement team. Many simultaneous developments are under way during this phase which require controlled planning and scheduling. A daily demand arises for correct compromises and systems integration between the many components and the air frame. Members of the WSPO team sit together and work together on a daily basis.

Limitation of WSPO Membership

The WSPO's could not be so effective in the weapon system objective if they were not periodically advised of the customers' thinking, war plan changes, and the daily accumulation of new requirements, as well as the supply, maintenance, and logistics aspects related to the weapon and the customer. Initially, the WSPO's were limited to resolving the problems that they as a small group could foresee and define in the design and procurement phases. The overall job in the design and procurement phase properly done involves a much larger team than the members of the WSPO.

Phasing Groups

Membership

These phasing groups hold monthly meetings and have experienced representatives from AMC, APGC, ATRC, the prime aircraft depot, often headquarters USAF, and, of course, most important, the individual specialists from the tactical commands. AMC membership includes not only the procurement and production representatives but also supply and maintenance. However, the latter two functions have been largely decentralized to the various depots, making it difficult for the WSPO, which operates as a continuous daily team, to include supply and maintenance members regularly. In practice, only periodic representation is required of supply, maintenance, the customer, etc.

Monthly Meetings

During the phasing group meetings we have encouraged each individual to "lay his cards on the table" and acquaint all concerned with his detailed problems. Seeing the whole picture at once immeasurably assists general integration of a complete weapons system. Specific responsibility is assigned during these meetings, and, with the problem defined, our people go to work. In this joint effort we seem to be approaching an automatic team relationship or a management group operating according to the weapons system concept.

We wish to add the industry team more positively to this group for all their products and supporting equipment. One of the biggest problems still remaining to be solved is providing the weapon systems with proper support equipment, and we are going to need much help from industry.

Industrial Modification

When a weapon is forced into production before the design is perfected it is difficult, if not impossible, to debug the arrangement completely during the various accelerated test programs. Some time after the aircraft have arrived in quantity at the tactical units a major modification program is a frequent requirement.

Since the tactical units themselves are extremely handy in the art of uncovering latent materiel deficiencies, it is both logical and economical to return the weapon to the manufacturer during its early life for depot-level maintenance and overhaul. Steps of this nature assist the manufacturer in early design correction of deficiencies, and the return to the plant is more for modification than mere maintenance.

Our present policy is not to expand our depot maintenance facilities but to maintain them at their present level. Any expansion required will be in industry following the weapon system concept of industrial maintenance mentioned above. We definitely intend to maintain a depot capability, however. The depots are taking care of our peak and valley loads, with industry picking up the more steady inflow portion of the job; this provides modification primarily during the newly developed and fully untried period and later during the modernization periods.

Recycling Complex Equipment

The regular, cycled maintenance of our complex equipment is also registering the impact of the weapon systems. For many years, we have selected various flying-hour figures at which the air frame and engines are removed for recycling and major overhaul. This is equally important where our complex electronic or electromechanical equipment is concerned. The time factor may vary between systems and even between the black boxes of a system, but the approach is sound, improves reliability, and is an economical investment for modernizing the billions of dollars invested in these systems.

In several cases, the problems associated with recycling have become so complex that we have established equipment phasing groups for such items as bombing navigation systems and fire control systems. Without reliability in the bombing system of a bomber, there is little need for more reliability of the engines, especially where we have as many as 10 engines on one bomber and only one bombing system. In other words, the team method that helps integration of all systems during the design of the weapon can serve a similar purpose during maintenance, overhaul, modification, and modernization phases. The equipment phasing groups live with the development, production, field support, and modernization of these systems.

I cannot emphasize too strongly the importance of this complete follow-through in the weapon systems management concept. Support equipment must be considered during design, during production, and during modification programs.

In the past, we have tended to concentrate on the air frame and engine, leaving the prime equipment to the second team and the support equipment sometimes to a third team.

It seems appropriate here to remind you that, despite the fondest hopes of industry, myself, and many others in the Air Force, we are never going to operate "just like any other business" for several very good reasons. We are always going to be subject to the decisions of Congress for funds, and we are always going to be planning for defense under constantly changing world conditions, so no matter how desirable it may be to formulate plans well in advance and then stick to them, the best we shall ever be able to do is approach that objective to the extent that the conditions imposed upon us will permit.

To obtain flexibility in any business requires that responsibility and authority be delegated as far down the line as possible. Now, flexibility in our business—if by that we mean the ability to adjust rapidly to constant program and engineering changes—is most necessary if we are to be able to get quick answers to our problems and to industry's problems. Here, again, we live in a

world of compromise. We try to accomplish two opposing objectives at the same time. Flexibility is essential to quick reaction to changes—and changes are one thing we can be sure of in the defense business—but, when we provide for flexibility, we have trouble with our other objective, standardization. You cannot have both at the same time, but both at the same time is what some people expect.

The problem recurs whenever we introduce new items not yet fully developed. We want the latest equipment in all our systems, but we also want it to operate reliably and to give long service. With the long development time now required for our complex equipments, if we waited for complete reliability before using the equipment we would certainly make our business safer, but we would not have a very modern Air Force. So we compromise—sometimes going too far one way, sometimes too far the other way—and reset our sights by periodic inventory.

Since, basically, AMC's job is getting materiel from industry to the other Air Force commands when and in the quantities needed, our problems are about the same during the initial airplane production stage and later during the support stage. The major difference is that different hardware is involved. In the first instance, we are concerned with the weapon, its components, and support equipment; in the second, with spares, kits for changes, and more usable support equipment. Maintenance and overhaul in our factories and depots is a big operation, but here also the big problem is getting the replacement parts required.

Our proposed objectives are to improve our operation in order to give more and better service to the Air Force customers and to industry, with whom we deal daily, and to provide more and better materiel with the taxpayer's dollar.

We are going to try to provide a single office in our organization where industry can get an answer and a decision or where the using command can get a complete story and some action on his problem.

It is important that industry give sufficient emphasis to support items, with early recommendations for what is required, in order that procurements may be realized concurrently with the end item. Any end item that reaches the field without support equipment always receives a bad name. It is dead weight in a logistics system, which just cannot afford dead weight. One of the best sales gimmicks that industry could possibly use would be that of ensuring an accurate support equipment list at the earliest possible date after signature of a contract. Less progressive industrial concerns will take the attitude that this is common support equipment, so let the Air Force worry about it. The smarter ones pitch in to get the wheels rolling, and we like, and insist on, this attitude.

Low-Level, Fast-Moving Inventory, with Quick Turn-Around

The logical objective of "weapon systems" in operation is a "low-level, fast-moving inventory," with quick turn-around between sorties. An aircraft that will meet reasonable contract performance can, of course, be designed by concentrating on the air frame and engines, with little thought to the complex equipments or support equipments. Not infrequently this happens. Even guided missiles, though they are single-mission weapons, cannot be supported logistically by short-sighted planning. Each strike mission still involves transportation, storage, periodic maintenance of the complete weapon, and such associated equipment as guidance stations, launchers, and many smaller test equipments. Modernization and maintenance to ensure shelf-life in itself calls for integrated preplanning.

Industry Teams

Briefly, those are some of the problems and our approaches to solutions through weapon systems phasing group management. It would be interesting to consider for a moment what parallel efforts in industry could contribute. In your own minds analyze this matter relative to the accessibility problem and the ugly mass of interconnecting multiwire cables and piping strung up and down through many an Air Force weapon. It seems obvious to me that the air-frame people must form a weapons team with the equipment and engine people, and all must ally themselves properly with the support equipment designers and manufacturers before we can arrive at the weapons system on the industrial side of the ledger.

Check Out and Plug In Like Refrigerators

Through this integration of design by the weapon systems industrial team, together with simultaneous consideration and development of the entire series of complex equipments and support equipments, our ultimate goal should be to:

(1) Produce and check out complete power plants at the engine plant.

(2) Produce and check out complete equipments at the equipment plants.

(3) Get the air frame fully checked out and ready.

(4) Deliver these items to the air-frame maker, who merely has to move the items to their predesignated slots, plug them in, and expect them all to run as well as the refrigerator sitting against your kitchen wall. Now why doesn't this happen?

Packaging Equipment

You may have been wondering why, when my topic is "The Air Weapon Systems in Operation," I keep returning to design. The two categories together result in a series of hardware items with many separate systems assembled throughout the United States. When all the systems are assembled in a single package, so that they work on an integrated basis, then we have the "weapon." It becomes "weapon systems in operation" when turned over to a combat unit, if:

(*Continued on page 62*)

Magamps Applied to Aircraft Control Problems

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THE NEED FOR MAGNETIC AMPLIFIERS in aircraft control circuitry is certainly well established today on the grounds of greater reliability and longer life. While constant strides are being made to improve the reliability of systems using vacuum tubes, it is still true that presently available tubes have about an 80 per cent survival after 500 hours of military use.† Wherever magnetic amplifiers have been applied to aircraft control circuitry, their only real problems have been in the initial manufacture and not in field service. Some of the aircraft applications in which magnetic amplifiers have found wide use in recent years are:

(1) Autopilots.
(2) Voltage regulators.
(3) Radar antenna servos.
(4) Power supplies in fire control equipment.
(5) Jet-engine controls.

As the self-saturating magnetic amplifier has been applied to aircraft control circuitry with an ever increasing rate in the past several years, the novelty of the device has often been stressed to the point where systems analysis engineers and mathematicians have become somewhat skeptical in handling a system study where magnetic amplifiers are involved. The fact that the total control circuitry effects the dynamic response and that gains are specified more often in terms of current than voltage can be confusing. Some justification for this point of view certainly exists, and the main purpose of this paper is to give a better understanding of magnetic amplifiers to those who are primarily interested in their function in a complete control system.

To elaborate further on this problem, it is true that the magnetic amplifier component designer works with nonlinear elements—saturating reactors and rectifiers. Analysis of the cycle-by-cycle operation is difficult, and little agreement has been reached as to the best set of simplifying assumptions to use.‡ Most of the design procedure is empirical, as it is, incidentally, for such common devices as electric motors. However, the quantities that are useful and important in the overall circuit are the average values of the load current or voltage, the average values of control current, and the time delays; fortunately, these quantities can be obtained accurately on any completed circuit. The transfer function of any magnetic amplifier can then be written if care is taken to define properly the "gain constant," the "dead time," and the "time constant."

To discuss these three transfer function parameters, a brief look into the amplifier "black box" is necessary in order to define terms. Since all types of self-saturating magnetic amplifiers are simply various combinations of a single-cored, self-saturating, half-wave circuit, we can define the following terms that are used in the rest of this paper with the aid of Fig. 1:

e_1	= d.c. control voltage
R_1	= total control circuit resistance
$i_1 = e_1/R_1$	= control current
N_1	= number of control winding turns per core
N_L	= number of power winding turns per core
E_{AC}	= a.c. supply voltage
R_0	= load resistance
e_o	= load voltage
$i_o = e_o/R_o$	= load current
$I_{o\ (av.)}$	= average value of load current

The familiar circuit types, which are listed in Table 1 and shown in Figs. 3 through 6, are easily understood to operate as combinations of this single-cored circuit giving half-wave, full-wave, a.c., d.c., single-ended, or push-pull outputs. If the output of the amplifier is a.c., the use of the average or the r.m.s. values of the current pulses will depend upon the application. For instance, an a.c. motor will produce torque proportional to the average value of the a.c. current pulses, while a heating element will be sensitive to the r.m.s. value. The gain constants must be determined and used accordingly.

Now the three major factors in the transfer function can be considered in order. First, the gain constant (K) of all d.c. ampere-turn controlled self-saturating amplifiers is best expressed as volts/amp.-turn—i.e.,

$$K(\text{volts/amp.-turn}) = e_o/N_1 i_1 \qquad (1)$$

Eq. (1) can be altered to express various gains such as volts/volt, amps./amp., etc. (Refer to Fig. 2.)

Voltage gain:

$$K_v = e_o/e_1 \qquad e_1 = i_1 R_1$$
$$K_v = KN_1/R_1 \qquad e_o = (N_1 i_1)\, K = e_1(N_1/R_1)K \qquad (2)$$

Transfer ohms:

$$K_R\ (\text{volts/amp.}) = KN_1 \qquad (3)$$

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* Special Systems Section, Air Arm Division, Engineering.

† Jervis, E. R., and Swauger, J., "Military Reliability of Electron Tubes," *Electronics*, Vol. 27, No. 4, p. 130, April, 1954.

‡ Finzi, L. A., and Pittman, G. F., Jr., "Methods of Magnetic Amplifier Analysis," *Electrical Engineering*, Vol. 72, No. 8, p. 690, August, 1953.

TABLE 1

Type	Refer to Figure	AIEE References	Output Quantity	Applications	General Transfer Function	Usual Parameter Values (400 Power)	Typical Value of K ($\frac{\text{Volts}}{\text{Amp Turn}}$)
Amp Turn Controlled:							
1. Doubler	3A	51-388	AC	Regulators	$\frac{K_e^{-sT_o}}{1+sT}$	T_o = .00125 sec	25
	3B	51-388	Phase Reversible AC	2 Phase Induction Motor Control	"	.005 T .05	50
2. Bridge	4A	51-388 49-140 53-284	DC	Regulator and Relays	"	"	25
	4B	51-388 49-140 53-284	Phase Reversible DC	DC Torque Motor Control	"	"	50
3. Center Tap	5A	51-388 49-140 53-284	DC	Rarely Used	"	"	25
	5B	51-388 49-140 53-284	Phase Reversible DC	Low Level Signal Amps.	"	"	50
4. Half Wave Circuits	6A	51-388 49-140 53-284	DC	Regulator	$K_e^{-sT_o}$	T_o = .0025 sec	12
	6B	51-388 49-140 53-284	Phase Reversible DC	DC Torque Motor Control	"	T_o = .0025 sec	25
5. N.O.L. Bridge	6C	51-388 52-235	Phase Reversible DC or AC	DC Torque Motor or 2 Phase Induction Motor Control	$K_e^{-sT_o}$	T_o = .0025 sec	25
Volt Second Integral:							(Volts/volt)
6. Half Wave	7A	51-388 51-217 51-389	DC	Regulator	$K_e^{-sT_o}$	T_o = .0025 sec	10 - 20
7. Ramey	7B	51-388 51-217 51-389	DC	Regulator and DC Torque Motors	$K_e^{-sT_o}$	T_o = .00125 sec	10 - 40

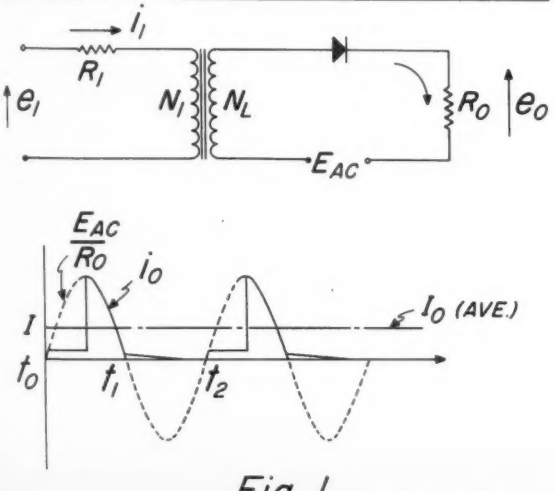


Fig. 1

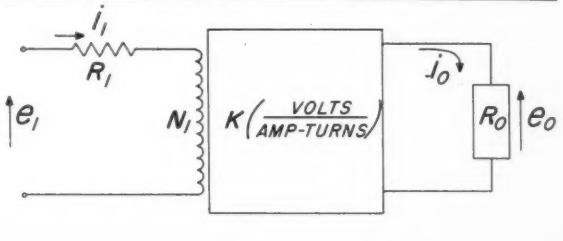
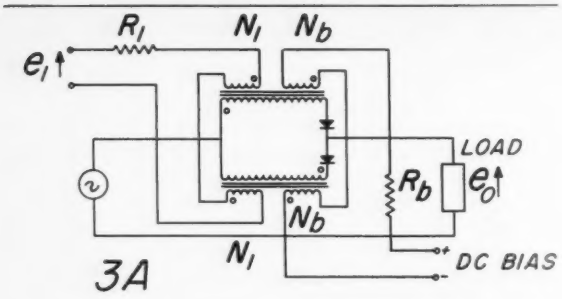
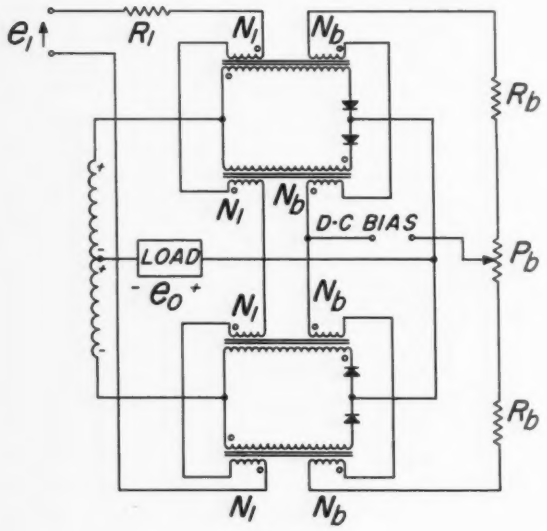


Fig. 2



3A



3B

Current gain:

$$K_I = K_R\,(1/R_o) = KN_1/R_o \tag{4}$$

If power gain (K_p) is required, it may be defined as:

$$\begin{aligned} K_p &= P_{\text{out}}/P_{\text{in}} \\ P_{\text{in}} &= (i_1)^2R_1 = e_1i_1 = (e_1)^2/R_1 \\ P_o &= (e_o)^2/R_o = e_oi_o = (i_o)^2R_o \\ e_o &= (KN_1/R_1)\,e_1 \\ P_o &= \frac{(KN_1/R_1)^2\,(e_1)^2}{R_o} \\ \frac{P_o}{P_1} &= \frac{(KN_1/R_1)^2\,(e_1)^2(R_1)}{(R_o)\,(e_1)^2} = \frac{(KN_1)^2}{R_oR_1} = K_p \end{aligned} \tag{5}$$

Secondly, we shall consider the "dead time"—i.e., the time constant (T_o) in a typical magnetic amplifier transfer function:

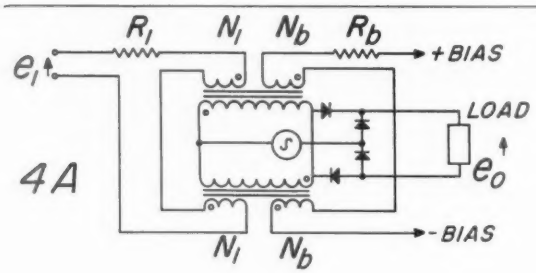
$$F(S) = \frac{Ke^{-sT_o}}{1 + sT} \tag{6}$$

To understand how T_o is associated with the operation of magnetic amplifiers, a knowledge of the control mechanism of the amplifier is required. Referring to Fig. 1, the two separate half-cycles of operation will be defined. First, the conducting half-cycle is that half-cycle during which load current (i_o) flows through N_L and is indicated in the interval between t_o and t_1. The half-cycle of conduction is determined by the direction of rectification in the output circuit. Second, the flux reset half-cycle is that half-cycle during which the power winding does not conduct useful load current.

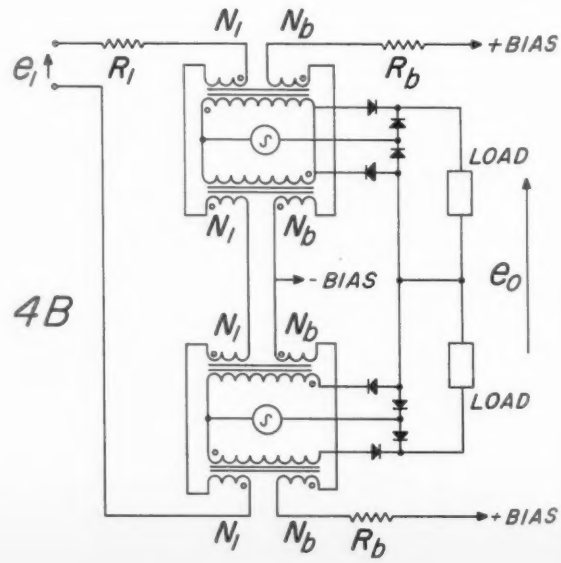
It is known that a change in the control current (i_1) is effective only during the flux reset half-cycle. It is this fact that accounts for the "dead time" (T_o). The maximum dead time for the half-wave amplifier shown in Fig. 1 is one cycle of E_{AC}. That is, $T_o = 1/f$ where f is the frequency of E_{AC}. For a full-wave amplifier the maximum dead time is one half-cycle of E_{AC}, that is, $T_o = 1/2f$.

All self-saturating magnetic amplifiers have this characteristic. In fact, any modulator device has the same property. The effect on a sinusoidal signal is exactly as the transfer function indicates, and for low-frequency signals (below 10 cycles per sec.) it can usually be neglected. However, the transient response is a function of the specific time within the supply frequency cycle at which the transient is introduced. Here, again, this fact may be neglected, or the maximum time may be used representing the worst condition of operation. The "dead time" delay of magnetic amplifiers may be decreased with an increase of the power frequency (frequency of E_{AC}).

Full-wave d.c. ampere-turn controlled magnetic amplifiers (single-ended or double-ended) have, in



4A



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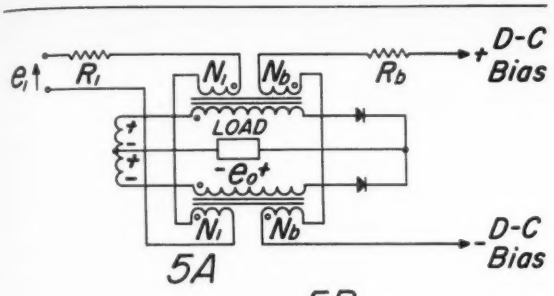

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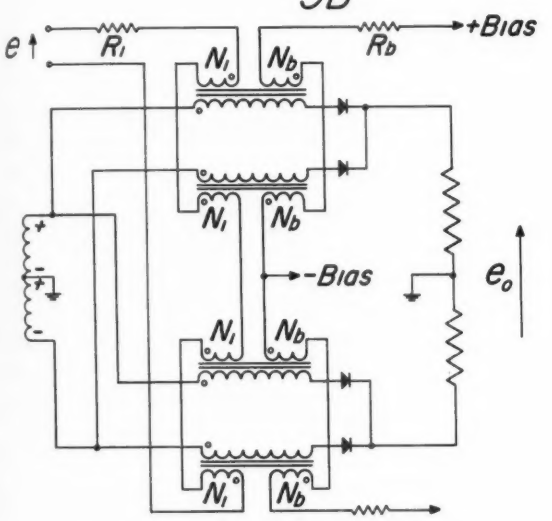

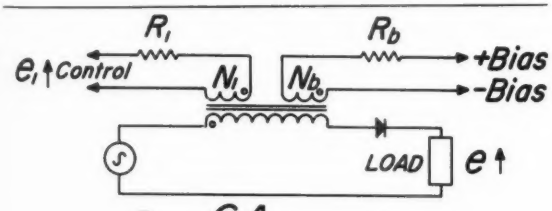

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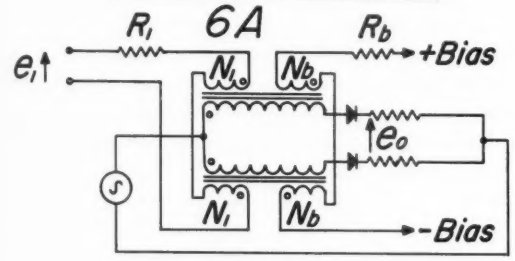

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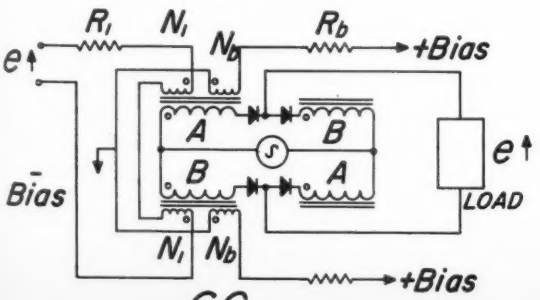


6C

addition to the "dead time," a "time constant" (T in Eq. 6). For discussion and derivation of the time constant of magnetic amplifiers the reader is referred to *AIEE* technical publications (1) 50–177, by Harder and Horton, and (2) 52–234, by Carlton and Horton. The time constant of the full-wave d.c. ampere-turn controlled magnetic amplifier is intimately associated with the control circuits of the amplifier. The above-mentioned technical publications show that:

$$T = a \sum_{i=1}^{n} \frac{(N_1)^2}{R_1}$$

where T is the time constant in seconds, n is the number of control windings, a is a proportionality constant, and $(N_1)^2/R_1$ is the contribution of the ith control circuit to the total time constant T. It is seen from the above that the time constant, T, is related to the gain of the amplifier. Referring to Eq. (5),

$$K_p = \frac{(K)^2}{R_o} \cdot \frac{(N_1)^2}{R_1} \qquad (5)$$

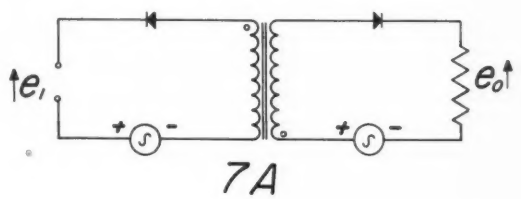
shows that the power gain of the amplifier is proportional to N^2/R as is T.

We now have defined and discussed the parameters in the transfer function of Eq. (6), which is typical for a single-stage magnetic amplifier. Table 1, therefore, becomes self-explanatory. It lists all common types of self-saturating magnetic amplifiers used for aircraft control systems together with:

(1) Circuit diagrams.
(2) Type of output.
(3) Typical application.
(4) Transfer function with typical parameters.
(5) Sources of more detailed information.

This reference table should be helpful as a check list in any systems analysis to ensure that all the param-

(*Continued on page 66*)



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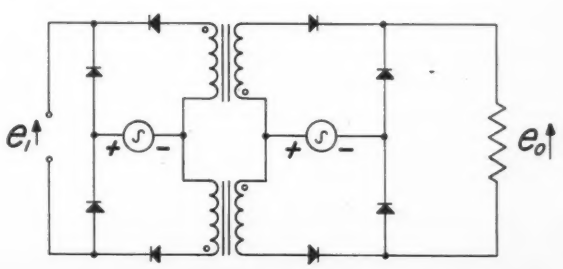

7B

Development of

Optimum Structure for Large Aircraft

L. M. HITCHCOCK*

Boeing Airplane Company

Introduction

There are available today at least two major techniques or methods for the design of aircraft structure. One of these is the so-called *stretch method*. In this method, the structure is initially designed understrength and the deficiencies corrected by means of a static test development program. In other words, the static test becomes a design tool, and it is apparent that lightweight structure can result. The second method involves designing the structure to support full design loads. It employs rigid weight control, reliable stress analysis methods, knowledge from past experience, and developmental testing for allowable stresses and loads to obtain light structure. It is this second method that will be discussed and demonstrated to be of overall advantage in the development of large aircraft. For convenience this method shall be referred to as *100 per cent design*.

The philosophy of 100 per cent design is considered beneficial in the development of large aircraft because it can:

(1) Result in lightweight structure.

(2) Assure that the static test program will be completed in a reasonable time period.

(3) Provide maximum continuity for the production program.

(4) Permit early flight test without excessive load factor restrietions limiting evaluation of performance, stability, and control of the airplane.

These are recognized as important items in all aircraft production development, but they are especially important for large aircraft. It is concluded that 100 per cent design satisfies all four of these needs, and that in this sense the method can yield essentially "optimum" structure.

Lightweight Structure

To achieve low structural weight by the method of 100 per cent design (or by any design method) it is necessary to follow a rigid weight-control program. We have found that one of the requisites in the weight-control program is the utilization of analytical methods for the preliminary weight estimates. These methods account for critical loads, geometric relationships, the method of construction, and the allowable stress levels of the materials. The refinements in method permit the evaluation of even small changes in the design parameters and improve the ability to determine efficient structural arrangements in the preliminary design stage. Once the airplane configuration is selected, it is our policy to establish optimistic "target" weights with minimum allowances for extra features and contingencies. This emphasizes the overweight effects of extra features and special design problems and thereby provides a constant challenge to offset such increases by design refinements. During the structural layout stages a continuous weight evaluation is made of the design development. The current weights are compared with the target weight allowances and periodically reported to all responsible design groups. Reasons for weight differences are carefully analyzed, and steps are taken not only to eliminate such overweights but also to better the target weights wherever possible. It follows, of course, that reliable stress analysis is necessary to achieve the desired goals.

It has frequently been held that practical analysis methods are not satisfactory for obtaining light structure. However, when analysis and experiment differ widely, it is probable that analysis has been applied without due regard to the limitations of the ever-present assumptions. Inasmuch as the magnitude and complexity of modern structural design problems make analysis indispensable, it has been our practice to modify analysis methods on the basis of the results of past tests for application to future designs. (The modifications are, of course, applied in the simplest manner consistent with good engineering practices.) With a continuous improvement in experience and judgment on this basis, it becomes possible to exploit analysis with the expectation of better correlation with experiment.

Correlation of analysis with test results enabled us to use the experience gained on the B-47 airplane more efficiently in the design of the B-52. Furthermore, the prototype jet transport we have built has a structure that is designed almost exclusively on the basis of judgment gained in analyzing and testing the C-97, B-47, and B-52 airplanes. By a process of review, fundamental conservatisms have been consistently reduced so that the analysis methods used are more applicable now than in the past. To collect significant facts from static test programs for review we have always liberally applied strain gages to well define stress paths and intensities. For example, on the B-52 program a total of 2,500 strain gage locations are used; 600 of these are recorded on one critical test condition.

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* Staff Engineer, Structures.

Another aid in the design of light structure is the extensive testing of joints, panels, composite structures, and representative components to find true allowable stresses and loads in the structure. In so doing we attempt to exploit the strength of the structure in the developmental test phase instead of in the static test phase as for the stretch method. For example, the B-52 program has involved over 130 test programs to determine the stress allowables to be permitted in all questionable locations. These tests included a true half-size model of the body in the region of the bomb bay and wheel wells. This is shown in the test stand in Fig. 1. The results of the tests on the model indicated the manner in which the torsion loads were transmitted, the allowable shear flows on skins of different thicknesses and radii, the influence of the support spacing, and the optimum cross sections of the body frames. These tests were extended beyond the elastic range to the ultimate strength of the model so the results were fully applicable to the ultimate design conditions of the airplane.

Our experience has confirmed that the methods just described will give light structure with fairly definable strength limits if the policies are pursued with sufficient vigor. Also, the method of 100 per cent design is found to be conducive to successful static test programs.

The Static Test Program

To be successful, a static test program must be completed within a reasonable minimum time period. It is important, then, to avoid excessive premature failures with their attendant delays. The bugaboo of premature failure is hard to avoid, as can be seen by referring to the static test mortality curve of Fig. 2. Here the abscissa is the strength level in percentage of design ultimate load, while the ordinate is the percentage of the major components tested that reached the strength level before first failure occurred. This curve presents the results of tests of many components and is representative of the average experience of the aircraft industry as of just a few years ago. The only significant similarity between the components tested is that all were estimated to be capable of supporting 100 per cent of the design loads or better.

We may divide premature failures into two types, the local and the catastrophic. Local failures are those that are only moderately extensive so that the test specimen may be repaired and modified for subsequent retesting in a short time. Catastrophic failures are those that are impractical to repair and retest without excessive delays and substitution of major sections or components built in the construction jigs.

Local failures can be troublesome even though they do permit the re-use of the test article. Fig. 3 is the "local" failure record experienced on the wing of the XB-29 airplane. After the first failure, additional strain gages were added to the repaired and strengthened wing as a control to anticipate other

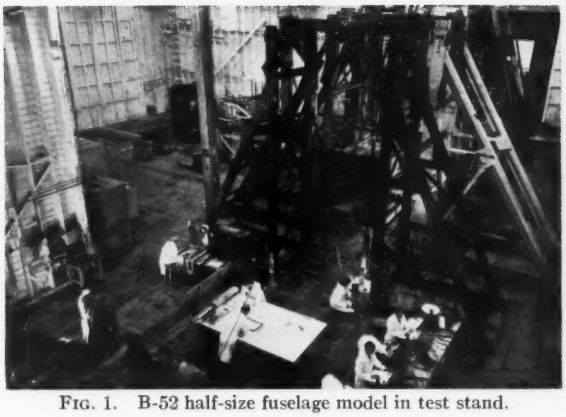

Fig. 1. B-52 half-size fuselage model in test stand.

failures so that the structure could be modified before failure actually occurred. From the subsequent failures that did occur, however, it is evident that strain gage control and visual observation are not guarantees against premature failure.

Catastrophic failure is well illustrated by the experience of testing the B-50 wing. The first failure in the program occurred at 92 per cent of load, and the result is shown in Fig. 4. It can be seen that the article is a complete washout. For subsequent testing it was necessary to replace the right outboard wing and the entire left wing and rework the right inboard wing. A second catastrophic failure occurred at 95 per cent of load, and it was once more necessary to replace entirely the left wing. Upon further testing the right wing failed locally at 99.5 per cent of load. This level was considered evidence of structural integrity for the condition tested with suitable minor changes incorporated. The reworked wing was subsequently tested to destruction in another condition at 101.5 per cent of load. The final cost of the program was approximately three times what it would have been without the premature

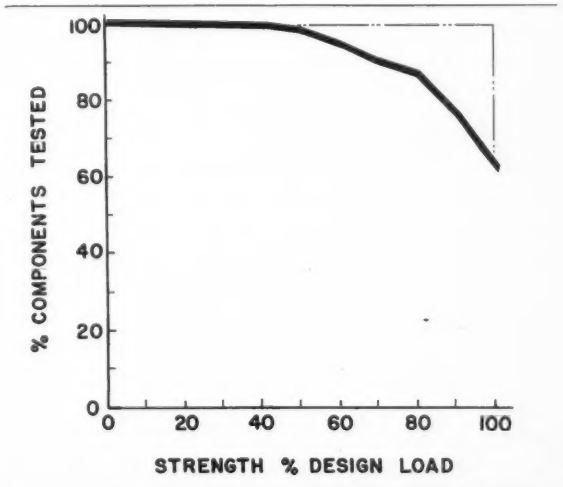

FIG. 2 STATIC TEST MORTALITY ON MAJOR AIRFRAME COMPONENTS

catastrophic failures. In regard to the effects of delay, the program was even more unsatisfactory. While the structures of the XB-29 and B-50 wings were geometrically similar and the test failures had similar origins, those of the B-50 were catastrophic because of the exploitation of a new high-strength aluminum alloy that frequently shows extensive shattering on failure. It is generally true for the high-strength alloys, which usually are brittle in nature, that incipient failure is difficult to detect and, upon occurrence, likely to be extensive.

The influence that premature failures can have on static test programs is illustrated in Fig. 5, in which are compared the actual and scheduled test times for the XB-29 and B-47 airplanes. As indicated previously, the XB-29 program had many premature local failures, and, as a result, the actual testing time was more than 13 months instead of the three months or so scheduled. On the other hand, the B-47 test program was completed with but few and minor premature failures so that the time schedule was exceeded by only two months. Further, the B-47 static test program was enlarged in scope after testing began. The scheduled time shown does not reflect this while the actual time does. The satisfactory experience of the B-47 program is attributed to a more successful application of the method of 100 per cent design.

Our past experiences have proved to us the need for completing static test programs without excessive delays. It is felt that this need is even more important today than previously, for with the increase in aircraft design complexity there has been an accompanying increase in the number of tests required in the static test program. This trend is illustrated by Fig. 6. For the future we must anticipate airplanes of still greater complexity with difficult environmental test problems so that delays will become increasingly undesirable.

The concern regarding static test delays is so great that, in spite of the advantages inherent in the method of 100 per cent design, we have considered it necessary to test initially to only 95 per cent of ultimate load in the critical design conditions. This procedure lessens damage in any one test which could precipitate premature failures in subsequent tests and generally reduces the probability of catastrophic failure and the attendant delays. Proof of 100 per cent strength is established by correlation between the 95 per cent tests, the stress analysis, and the ultimate destruction tests. The destruction tests are conducted for the condition most critical for each major component of the airplane.

It was previously stated that premature failures are difficult to avoid, but our experiences to date with the method of 100 per cent design and the policy of testing to 95 per cent of load have shown that premature failures in lightweight structure may be minimized and static test delays reduced to a level that can be tolerated.

Production Continuity

In addition to the problems of designing light, efficient structure and completing the static test program without excessive delays, there is the related need of maintaining production schedules with a minimum of disruption. From our experience on large airplanes, the production model design usually begins before the completion of the X-airplane, and production starts before the static tests. Frequently it will be found that the prototype is so different in concept from the production airplane that its structure is not representative of the production series. This was the case on the B-47 series, in which the X-model was not static tested, while the B-model, with a stronger structure, was. The last large airplane prototype that we static tested was the XB-29. However, even in this instance, the B-29 airplane was in production at the time the static test was being conducted on the XB-29.

The static test airplane is usually the first of the production series and production is concurrent with the static test program. Obviously, then, the design of the structure must be reliably finalized before extensive production tooling can be constructed. Production items, such as forgings, extrusions, and so on, require considerable lead time so it is necessary that the static test be completed, insofar as possible, without turning up major deficiencies in these items. While premature failure in static test may indicate only superficial structural changes, these may have a more serious influence on production parts and tooling.

We have also found that the size of the airplane can have an influence on the relations of the static test and production programs. For example, because of the size of the B-52 airplane, it has been necessary to use a part of the production area as the test facility. The test setup for the B-52 is illustrated in Fig. 7. The area used is about one-fourth that of a special hangar used for final production and flight testing of the production airplanes. As new designs are tested only about every four years, it is not economically feasible to provide a facility of the size required, suitable for static testing only. Here, again, it is important to minimize the delays of the static test program because of disruptions that could result to production schedules.

Aside from the direct influence of premature static test failures on production tooling, the changes to be made to items already produced must be considered. In the case of the B-50 wing, it was necessary to modify 20 existing wings because of the deficiencies discovered in static test. This incident, however, was insignificant in comparison to the difficulties experienced on the B-29 production program at Wichita. The delays resulting from the premature failures on the XB-29 prevented completion of the static test in the scheduled time, as mentioned earlier, so that much early production had to be modified to incorporate the changes determined as a result of the static tests. One of the more undesirable features of the situation was the neces-

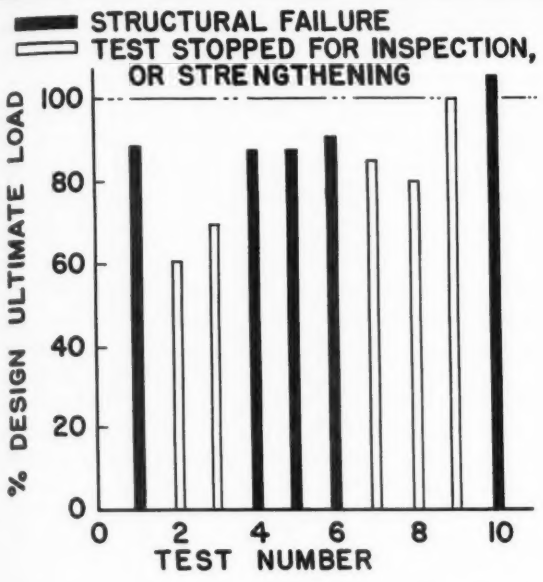

FIG. 3 XB-29 WING STATIC TEST RECORD

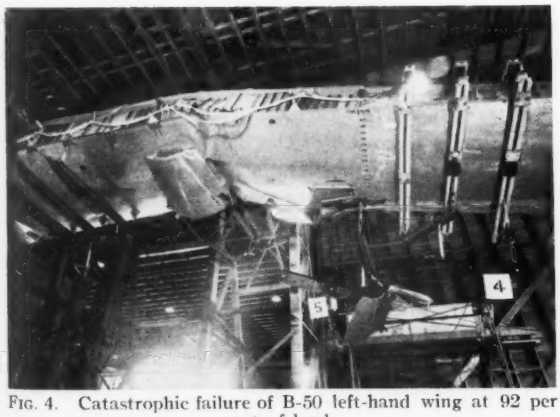

FIG. 4. Catastrophic failure of B-50 left-hand wing at 92 per cent of load

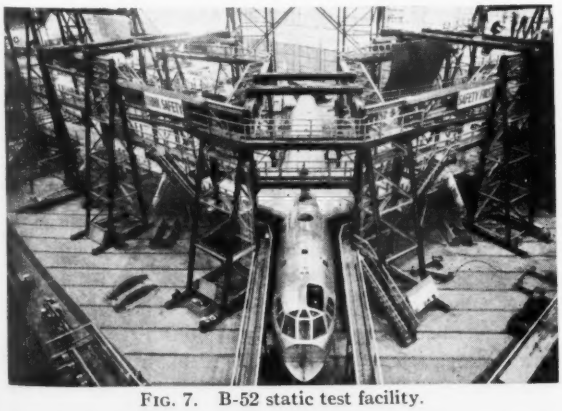

FIG. 7. B-52 static test facility.

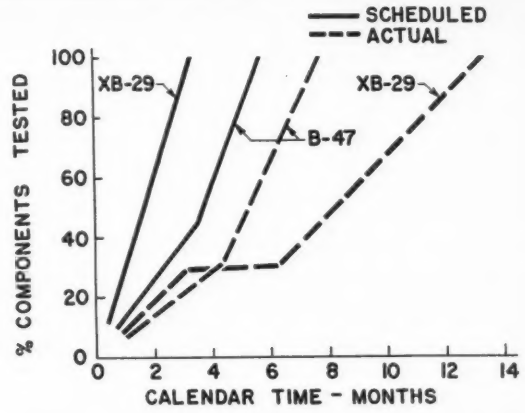

FIG. 5 SCHEDULED STATIC TEST TIME VS ACTUAL TIME

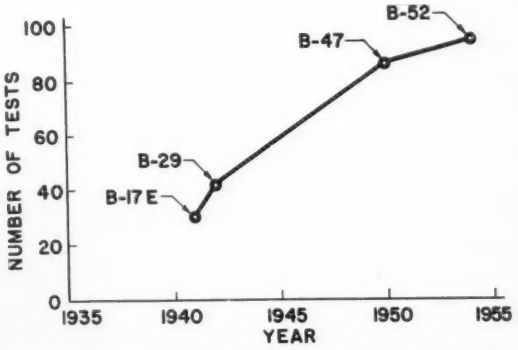

FIG. 6 INCREASE OF REQUIRED TESTING WITH DESIGN ADVANCES

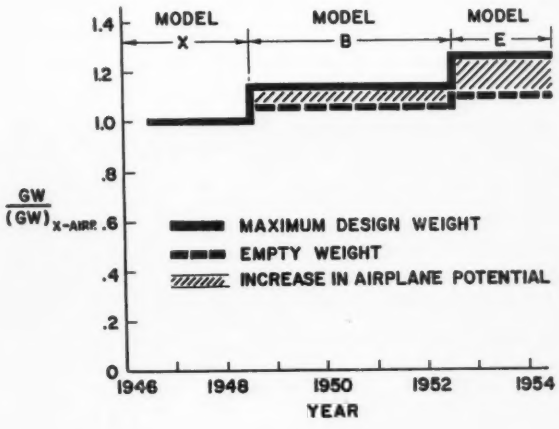

FIG. 8 B-47 GROWTH

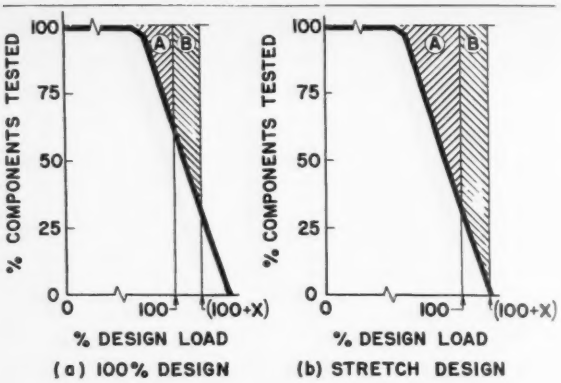

FIG. 9 COMPARISON OF STATIC TEST MORTALITY – 100% DESIGN VS STRETCH DESIGN

sary diversion of effort from production to static test fixes in time of war. Since these early unsatisfactory experiences, we have been especially careful in designing structure that will be of satisfactory weight and will still come through the static test without excessive premature failures or serious structural faults that cause excessive delays and disrupt production. On the whole, and in spite of some past difficulties, the method of 100 per cent design has enabled us to conduct production and static test programs concurrently, with good results. In fact, such a situation exists for the B-52 airplane today.

Early Flight Testing

On most Boeing designs, flight testing has commenced prior to the static test program. For safety, the airplane is speed and load factor restricted below design limit values until the static test program is completed. By designing to 100 per cent of load, the load factor limits permitted are reasonably adequate for evaluating the performance, stability, and control characteristics of the airplane. It is particularly important that the limits be set as high as possible on low load factor airplanes, such as heavy bombers and transports, so that a proper evaluation can be made. For these airplane types, structure design to less than 100 per cent of load, as in the stretch method, could be so marginal that complete flight evaluation would not be practical. We have found that the method of 100 per cent design has provided adequate strength for safe flight, providing even for the inadvertent exceedings of the restrictions which sometimes occur.

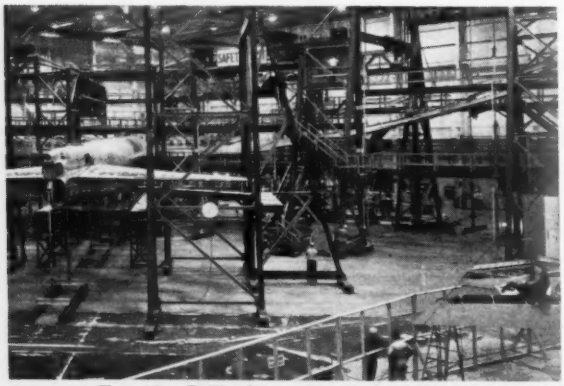

FIG. 10. B-52 wing at 85 per cent of load.

Additional Considerations

The method of 100 per cent design does give lightweight structure that is compatible with the needs of the overall airplane development program. It will not give the lightest possible structure for a given airplane, but, for that matter, neither will any other method that is economically feasible. Accordingly, it is generally expected that the 100 per cent design may give strength slightly in excess of that needed for the immediate airplane loads. This excess is not waste for it may be utilized in enlarging the concept of the airplane.

That successful airplane designs experience growth has been historically demonstrated many times. All Boeing production designs have experienced growth. A notable example of this is the B-50 airplane, which is largely identical to the B-29 in geometry but vastly improved in gross weight and pay-load limits. It is worth while to illuminate this further by examining the growth of the B-47 airplane in some detail. The graph of Fig. 8 shows how the gross weight of the several models has varied over the years since the detail design was started on the X-models. The ordinate of the graph is the ratio of the new gross weight to the original gross weight established for the X-model. Lengths on the abscissa roughly represent the duration of the particular model concept. The maneuver criteria of each model are the same so that gross weight increases are not made by a reduction in limit maneuver load factor. The structure was appreciably strengthened in going from the X- and A-models to the B-model, but the further weight increase on the E-model was made possible by exploiting excess strength disclosed in the static test of the B-airplane (though the increase is also partially applicable to the B-model as well). The difference between the empty weight line and the design weight line indicates that an increase in airplane potential was gained on each model.

It is in anticipation of just such growth that we have exploited our static test programs by failing the structure in as many parts, and for as many conditions, as is practicable. For example, the ultimate strength of the B-47B wing was fairly well established for the entire span by failing the inboard and left-hand outboard wings in positive bending and the right-hand outboard wing in negative bending. Applied to the whole airplane, this procedure fully discloses the growth that may be immediately available and minimizes the structural changes that may be required for future growth. It is apparent from previous statements that the limited excess strength of the B-47B was used. This permitted

an increase in the ratio of maximum gross weight to weight empty, with the range performance benefiting.

It is not claimed that growth should be considered in the original airplane design, but it is believed that the method of 100 per cent design holds definite advantages over the stretch method when it is accepted that, historically, growth may be expected. Based on the past experience of premature failures in static test, as illustrated in Fig. 2, and remembering that the stretch method involves initially underdesigning the structure, we might hypothesize accumulated failure records for several designs and compare the two methods, as shown in Fig. 9. The differences in the areas marked A, then, are an indication of the different amounts of work required to bring the airplanes up to the original design goals indicated by the 100 per cent load lines. The areas marked B are a rough measure of the differences in effort required by the two methods to increase the load-carrying capacities of the structures to a level of $100 + x$ per cent. In the long run, a positive advantage must accrue to the 100 per cent design method, for, while the details of Fig. 9 are not explicit, the above implications are certainly valid.

Conclusions

It is apparent from what has been said that inordinate delays are what must be avoided. We have not used the stretch method of design, but our experiences as described on the B-29 and B-50 airplanes are believed indicative of what may be expected in testing stretch designs and lead us to the conclusion that the delay potential of this method is too great for large airplanes. On the other hand, the philosophy of 100 per cent design has proved practical in reducing delays in the static test and production programs and in permitting early flight-test evaluation of the design and has given acceptable lightweight structure. Furthermore, aside from satisfying the direct needs of the production program, it is obvious that 100 per cent design offers better growth possibilities than the stretch method. In view of all the benefits obtainable by the method of 100 per cent design in the airplane production development program, it is proper to classify as optimum the light, efficient structures that can be designed by this method.

It is agreed that in favorable circumstances the stretch method can be extremely satisfactory. However, it must be understood that it is not applicable to all types of airplanes in all circumstances. Somewhere there must be a limit, and we are convinced that it is far below the modern heavy bomber or transport. Those who accept this premise with reluctance may refer to Fig. 10—which shows the B-52 wing at 85 per cent of load in the static test jig—and, recognizing that the wing is of nearly uniform strength so that one section is as susceptible of failure as another over a structural half-span of 105 ft., that it has a multiplicity of joints and splices, that it is constructed of machine-tapered elements, may contemplate the possibility of determining the so-called "optimum least weight" structure of this "behemoth" on a cut-and-try basis.

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SINCE THE BEGINNING OF FLIGHT our vertical advances have been measured in feet above sea level. Feet of altitude are used in compiling data of ceilings and altitude records of aircraft. We must realize, however, that in doing so we use an arithmetic measure while traversing a zone—namely, the atmosphere—in which the principal physical characteristics—namely, density and pressure of air—decrease in a geometric progression.

The broken line in Fig. 1 depicts the altitude records of aircraft since 1910 in feet of altitude (right scale). The development is characterized by two sudden advances—one in the early Thirties, when the perfection of superchargers and oxygen equipment pushed the ceiling to over 50,000 ft., and the second in the Mid-Forties, when rocket aircraft entered the scene. An extension of record altitudes measured in feet is indicated by the dotted line extrapolating the past and present data.

A better picture of our progress in high-altitude flight is obtained if we reckon altitude in terms of a geometric sequence, such as expressing height in terms of per cent of atmospheric mass left above the ceiling. We then use a measure characteristic of the medium through which we progress; the result is the curve represented by the solid line in Fig. 1 (left scale). Now we recognize that our efforts in increasing the ceiling of aircraft have already approached the horizontal section of an asymptote. At the record altitude of 85,000 to 90,000 ft. above the ground, about 97 to 98 per cent of the atmosphere's mass is below the pilot, whereas less than 3 per cent separated him from the emptiness of space. When altitude is presented in this way, it becomes immediately apparent that man and machine are currently operating in the area between atmosphere and space. Our future advances will proceed along the extrapolated asymptote causing high-altitude flight to blend gradually with actual space flight in its commonly accepted meaning.

The conclusion we must draw from Fig. 1 is that our present, and future, high-altitude flights take place in an atmosphere whose pressure and density are equal to or less than 3 per cent of the corresponding values at sea level. This, of course, implies a number of drastic changes in the environment of man and machine, since the density and pressure of air in which we operate are the most important elements of flight. The atmosphere fulfills a number of significant functions for both man and machine, and the extent to which the atmosphere is capable of rendering its important services is directly related to the density, pressure, and atmospheric mass found above the ceiling of the airplane. Table 1 lists a number of these functions together with the altitudes at which each of these functions falls short. According to Strughold et al.,[1] these critical heights have been called "functional borders of space."

The region of the atmosphere where its various functions for man and machine begin to cease and where space-equivalent conditions are gradually approached is called the "aeropause."[2, 3, 30] The aeropause encompasses approximately the region between the 10- and 120-mile levels; this region is equivalent with the upper last 12 per cent of atmospheric mass. Comparing Table 1 with Fig. 1 we recognize that present, and future, altitude flights take place in the region of the aeropause.

At the peak altitude of experimental rocket aircraft, the first three functions of the atmosphere have already fallen short. This means that, during these flights, the failing functions of the atmosphere must be replaced by artificial means in order to enable man and machine to operate at these heights successfully. In these aircraft the pilot sits in a pressurized cabin that preserves an artificial atmosphere of a pressure and density compatible with physiological requirements—i.e., meeting the pilot's respiratory needs and preventing his body fluids from boiling. Because an explosive decompression at heights in excess of 50,000 ft. is extremely

TABLE 1
Functional Borders of Space

Function	Altitude, Miles	Per Cent Atmospheric Mass Above Ceiling (Approximate)
Contributing to respiration	10	13
Preventing boiling of body fluids	12	8
Sustaining combustion of fuels	13–15	5.5–3.5
Absorbing cosmic ray particles	13–23	5.5–0.5
Absorbing solar ultraviolet (210–300 mμ)	22–28	0.6–0.15
Supplying aerodynamic lift	50–60	0.0045–0.00045
Supplying diffuse daylight	60–90	0.00045–0.000017
Absorbing meteors	65–95	0.00020–0.000010

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critical, pilots are given added protection in the shape of pressure suits. The airplane itself is equipped with rocket engines that are independent of atmospheric oxygen.

In future flights beyond the altitude level reached up to date, man and machine will be exposed to the accumulating hazards of the aeropause listed in Table 1. It therefore becomes important to determine the approximate durations of future flights in the aeropause. The following conclusions are based on a study of H. Haber.[4]

Any further progress in the direction of greater altitudes can only be made with the use of the rocket engine. This type of engine, however, consumes fuel at such high rates that we are forced into adopting a radically new type of operation of aircraft—namely, attaining a great velocity during a brief period of powerful propulsion and following through the rest of the trip by coasting with dead engines. From this principle it follows that the maximum attainable altitude and the duration of flight are dependent upon the maximum velocity of the rocket craft. Referring to Table 1, we find that aerodynamic lift and, correspondingly, drag vanish at heights of about 50 to 60 miles. This figure, however, is based on a velocity of the order of 5 miles per sec., and we must expect that lift and drag will become negligible at lower levels if the speed of the craft is less than 5 miles per sec. From this it follows that a rocket craft coasting through the atmosphere at heights above 40 miles is subject to only one force, namely, the force of gravity. Its motion, therefore, can be calculated by using the theory of celestial mechanics. In other words, after burn-out the craft will describe the arc of an ellipse whose elements depend on three variables: (1) the velocity at burn-out, (2) the altitude at burn-out, and (3) the angle of tilt of the craft at burn-out. Assuming reasonable values for the quantities (2) and (3), maximum altitude and duration of coasting flight—which comprises the major time of a flight through the aeropause—become functions of the speed at burn-out and can be computed. The results of the calculations are shown in Figs. 2 and 3. These graphs are believed to give a fairly good approximation of what to expect in terms of altitude and duration of flight as the speed of our craft increases to approach finally the range of cosmic velocities.

Fig. 2 gives the maximum altitude attainable as a function of speed in miles per second. The altitude levels off at a height of about 85 miles at a speed of about 1 mile per sec. Flights beyond the 100-mile mark can be accomplished only with a speed in excess of 3 miles per sec. The plateau of the curve between 1 and 3 miles per sec. is caused by the fact that for increasing speeds the trajectory of the craft must become shallower in order to enable a pull-out maneuver after the craft dives back into the denser layers of the atmosphere. Unmanned missiles that can be expended with the flight are able to rise vertically; with a maximum speed of about 1.5 miles per sec., the second stage of a two-stage rocket has reached a height of 250 miles, a point that lies well above the plateau of the curve. Upon approaching a speed of 4 miles per sec. and over, the maximum altitude rises steeply and finally becomes infinite when escape velocity—6.96 miles per sec.—is reached.

Fig. 3 gives the duration of coasting flight in seconds as a function of speed. These durations give a measure of what to expect in the future as the speed of our airplanes increases. This graph, too, exhibits a pronounced plateau between present-day speeds and speeds of the order of 3 miles per sec. In this range of speeds the coasting phase lasts about 4 to 6 min., and only at speeds in excess of 4 miles per sec. does the duration of flight increase. The time of coasting flight becomes infinite as soon as orbital velocity—about 4.6 miles per sec. plus the rotational speed of the earth—is reached.

An evaluation of the graphs depicted in Figs. 2 and 3 leads to two conclusions:

(1) For a long time to come manned flight will be restricted to the aeropause and will last between 3 to 6 min. only. Upon approaching a speed of 4.5 to 5 miles per sec., aviation will develop into space flight in an extremely rapid transition.

(2) We are about to enter a new phase of operation of aircraft which will lead into what can be called space flight for a limited period of time. Once we have reached a speed of about 1 mile per sec. in manned flights, we shall enter the plateaus indicated by Figs. 2 and 3, and the conditions to which man and craft will be subjected will not change materially all during the period when the speed of airplanes increases to about 3 miles per sec.

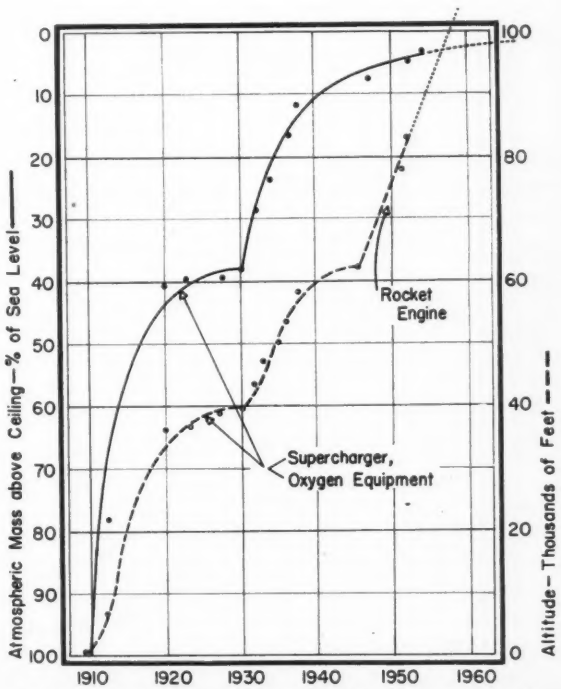

FIG. 1. Record altitudes of aircraft since 1910, espressed (1) in feet, broken line, right scale; (2) in atmospheric mass above ceiling, solid line, left scale.

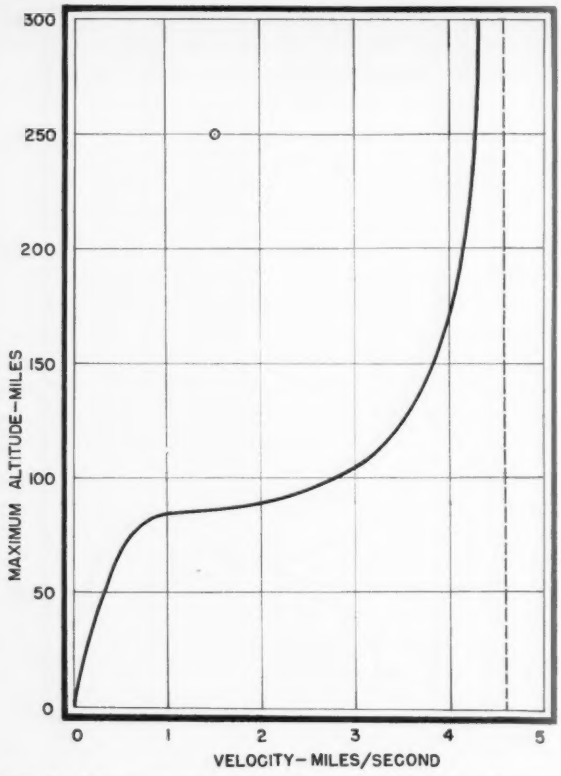

FIG. 2. Maximum attainable altitude of manned aircraft, as a function of speed in miles per second.

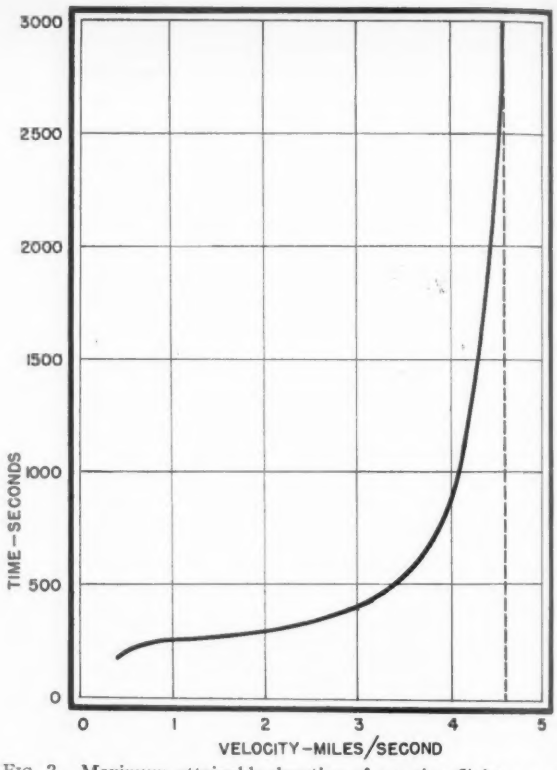

FIG. 3. Maximum attainable duration of coasting flights, as a function of speed in miles per second.

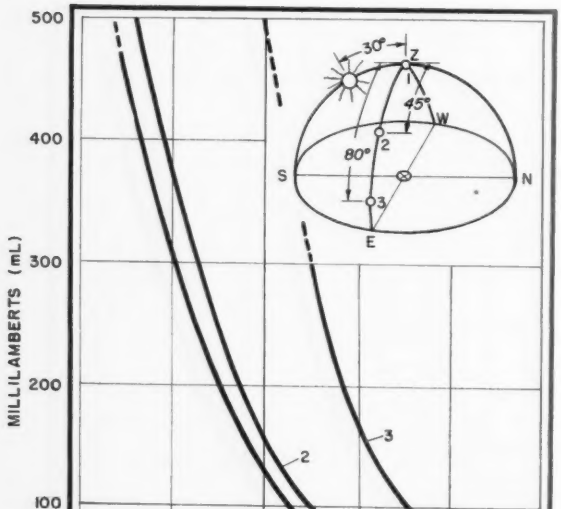

FIG. 4. Sky brightness in millilamberts for three different points of observation, as a function of altitude.

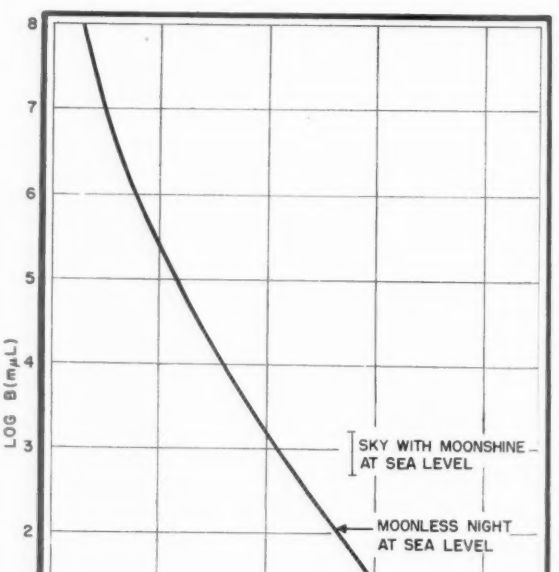

FIG. 5. Zenith brightness in micromillilamberts, as a function of altitude.

We must indeed expect that any further progress into the aeropause beyond the height reached in the past will have to be accomplished in coasting maneuvers because the structure of the atmosphere appears to be unsuitable for sustained flight. This problem was recently most succinctly stated by F. Haber.[5] Consider, for instance, a certain altitude—let us say 200,000 ft. Judging from present-day standards we can conclude that the maximum permissible speed at this height is about 5 Mach. Flying faster than this would produce so much aerodynamic heat that the aircraft would become too hot. However, at this altitude, the density of the air is more than 3,000 times lower than at sea level, and it takes a certain speed for the aircraft to derive enough aerodynamic lift from this vastly attenuated air. Using present-day wing-loadings as a standard, we find that we must fly with at least 10 Mach in order to remain air-borne. We then have the choice between two alternatives: either we can fly at 10 Mach and burn up, or we can fly at 5 Mach and fall down. In the first case we are too hot, and in the second case we are too slow. Should we attempt to fly at 7.5 Mach, we are too hot *and* too slow. In other words, we cannot fly at all at a height of 200,000 ft. In the present state of the art of flying, we can operate an aircraft in sustained flight only to a maximum altitude of about 100,000 ft. The conflicting conditions are resolved only at heights in excess of 400,000 ft. where the air becomes so thin that even a speed of 24 Mach would not produce aerodynamic heating great enough to become a danger to the ship. At this speed, however, aerodynamic lift is no longer necessary because the ship is supported against gravity by centrifugal force attending its fast motion around the earth. The ship has then become a satellite of the earth. Propulsion is only necessary to overcome what little friction is still present at this altitude. At still greater distances from the earth, all friction from the air would be gone entirely, and the ship could coast around the planet indefinitely without the necessity of being propelled. Meanwhile, however, the atmospheric regions between 100,000 and 400,000 ft. appear to be unsuitable for sustained flight. It looks as though Mother Nature has failed to provide us with an atmosphere whose structure would permit us an easy operation of aircraft at all levels of altitude. The engineering problems to be solved are obvious: better heat-resistant materials, smaller wing-loadings, and better aerodynamic configurations are necessary for extending our present high-altitude flights into new frontiers.

If we accept the conclusions that can be drawn from the present-day standards of the art of flying, we must indeed expect that the first exploration of the altitude ranges above 100,000 ft. or about 20 miles will be accomplished in coasting flights. Table 1, in combination with Figs. 2 and 3, will then permit us to assess the various human problems that the next future of manned flight involves. These hazards must be assessed with regard to the comparatively short times of exposure—i.e., of the order of 4 to 10 min., which includes a certain fraction of the ascent and descent.

These periods of time are likely to exclude a number of problems that are apt to become serious only if the time of exposure is prolonged to hours, days, or even weeks. Among these are cosmic radiation and the danger from meteorites. The density of the latter in space is too small to constitute a hazard for short times of exposure. The same can be said about cosmic rays, at least as far as our present-day knowledge concerning their biological effectiveness is concerned. A number of investigators in this country and abroad—notably Schaefer,[6–9] Tobias,[10] Storer, Furchner, and Krebs,[11] Simons,[12] Chase,[13] Eugster,[14] Birge,[31] and Campbell[32]—have recently studied this question. From their studies the conclusion emerges that short-time exposures to cosmic radiation at heights in excess of 20 miles do not constitute a serious hazard to health; but the question of tolerance of primary cosmic radiation over prolonged periods of time still appears to be open.

At heights above 25 to 28 miles the atmospheric ozone no longer affords protection against ultraviolet radiation from the sun. Buettner[15] has evaluated the hazard to health from these radiations using available data on the biological effectiveness of ultraviolet rays and on atmospheric ozone. His results indicate that erythema of the skin and damage to the eyes can be expected to occur in the aeropause 10 to 50 times faster than at sea level. This means that an exposure to solar radiation above the ozone layer lasting a few minutes only will have damaging effects. For this reason, window materials capable of absorbing ultraviolet light must be used in all vehicles designed to fly in the aeropause.

At greater altitudes visual problems arise because the diffuse illumination provided by the light of the sky becomes more and more attenuated. These problems deserve attention even though the exposure is short, because degree and kind of illumination inside and outside the cockpit are of great importance for the visual comfort of air crews.

When looking toward the sky the observer's gaze penetrates a long cone of air filled with molecules capable of scattering light. The total amount of light reaching the eye of the observer as a consequence of the scattering processes is perceived as the light of the sky. Its color is preponderantly blue, since the flux of scattered light increases rapidly with decreasing wave lengths. In the direction toward the zenith the number of air molecules along the line of sight is smallest, and the sky, therefore, appears darkest at this point. The light of the sky increases with increasing distances from the zenith of the point of observation.

Progressing to greater altitudes, the number of air molecules above the observer is gradually depleted, and, as a consequence, the light of the sky decreases. By the same token, the pilot of a high-flying aircraft is partially deprived of the diffuse illumination provided by the light of the sky, and he finds it increasingly more difficult to perform visual tasks such as reading instruments and orienting himself inside the cockpit. For this reason it becomes necessary to obtain information concerning

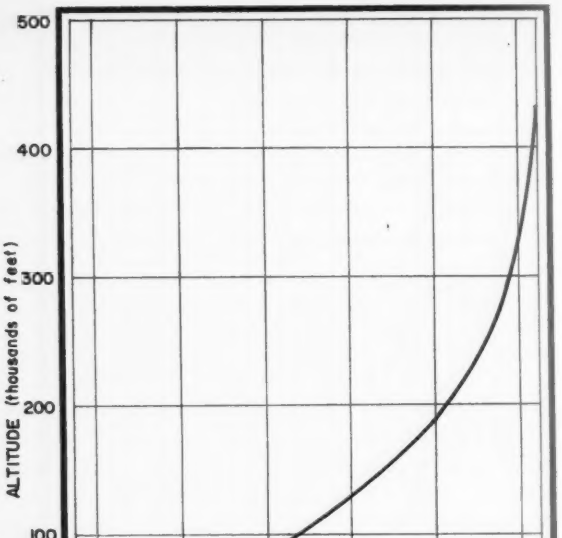

FIG. 6 Stellar magnitude of stars visible at increasing altitudes (threshold values).

the attenuation of the light of the sky at increasing levels of altitude.

Various authors have presented theoretical treatments of sky brightness and its dependence on altitude and zenith distance. The following discussions are based on the work of Tousey and Hulburt,[16] who have developed a rather complete theory of sky brightness. Besides brightness arising from rays of the sun directly scattered into the eye of the observer, these authors have also considered multiply-scattered sunlight. Multiply-scattered light reaches the observer after having been scattered by the surrounding atmosphere or after having been reflected from the ground.

The brightness of the daylight sky at a particular point of observation located on the hemisphere depends on the zenith distance of the sun, the difference in azimuth between the sun and the point of observation, the mean reflectivity of the earth, the absorption of atmospheric ozone in the visible section of the spectrum (Chappuis band of ozone[17]) and, of course, the altitude. Using the theory of Tousey and Hulburt, the brightness of the sky can be calculated as a function of altitude. Although the theory was not designed to stand an extrapolation to extremely high altitudes, values up to 400,000 ft. are given below in expectation that the data represent at least an approximation. Fig. 4 shows the sky brightness in millilamberts for three different points of observation, as a function of altitude. The locations of the three points on the hemisphere are as follows: (1) zenith, (2) at a zenith distance of 45°, and (3) at a zenith distance of 80°. Points (2) and (3) lie on the eastern meridian of the sky while the sun is assumed to be on the southern meridian at a zenith distance of 30°. As can be seen from the graph, the brightness of the sky at a height of 100,000 ft. is about 1/30 of the corresponding values at 10,000 ft. Fig. 5 shows the extension of the zenith brightness up to altitudes of 500,000 ft. According to this latter figure, the light of the sky vanishes completely only at very great altitudes. At a height of 300,000 to 400,000 ft., the zenith brightness is still approximately the same as that found during a clear night at sea level with the moon shining. At heights of 450,000 to 500,000 ft., the zenith brightness approaches that of a moonless night at sea level. From there on, the blackness of space is complete.

Owing to the decreasing brightness of the sky with increasing altitudes, stars become visible during the day. The observability of stars at higher altitudes is of aeronautical interest insofar as celestial objects other than the sun can be used for purposes of celestial navigation. Weaver[18] has compiled data on the visibility of stars of various magnitudes as a function of sky brightness. Using his data in combination with the sky brightnesses above, we can calculate the observability of stars at various levels of altitudes. Results are shown in Fig. 6.

When looking down from an aircraft cruising at high altitudes, the eye meets brightnesses of varying levels depending on the features of the landscape and meteorological conditions. Looking up, the daylight sky appears as the only source of light. Most features on the ground, the clouds, and other sunlit objects are rather bright, whereas the sky brightness is low, even at moderate altitudes. Owing to these conditions strong contrasts of simultaneously perceived brightnesses are produced. Some brightness values to be expected from the ground, the clouds, and sunlit parts of the aircraft's structure are given in Table 2.

Guth[19] has established contrast values that produce an initial momentary sensation judged to be at the borderline between comfort and discomfort (*BCD*). The critical contrast values depend upon the brightness of the target, the solid angle Q subtended by the target, and the brightness of the background, B_b, in the following fashion:

$$BCD = 108\, B_b^{0.44}(Q^{-0.21} - 1.28)$$

whereby the brightnesses are given in foot-lamberts (1

TABLE 2

Brightness Levels Encountered in Flight

Object	Brightness, Millilamberts
Sea (specular reflection)	60,000–200,000
Clouds of various types	1,400–10,500
Snow*	6,300–9,000
Fields	1,100–3,000
Forests	400–1,200
Sea (nonspecular reflection)	300–800
Mean of total earth	4,200
Sunlit parts of aircraft structure	1,000–100,000
Solar disc	700,000,000

* Zenith distance of the sun in this case is 60°; in all other cases 30°.

foot-lambert = 1.0764 millilambert). From the data of Guth it can be concluded that viewing objects at higher altitudes will frequently be the cause of great visual discomfort. Even at moderate altitudes, objects having a reflectance as low as 20 or 30 per cent surpass the comfort threshold, if they are illuminated by the sun when viewed before the background of the sky. For an object the size of an aircraft wing, the comfort threshold is exceeded at altitudes of 10,000 ft., even if the reflectance of the wing surface is only 25 per cent.

Discomfortable brightness contrasts will be encountered inside the cabin of a high-flying ship where sunlit patches will be seen adjacent to deep shadows. Owing to the small illumination afforded by the light of the sky, the interior of the cabin will be rather dark, making orientation inside the cockpit and the reading of instruments difficult or impossible. These conditions of lighting will produce fatigue, strong visual discomfort, and glare. Cibis[20] has suggested the use of light-diffusing panels to cover a certain section of the window area and shield the interior of the cockpit against the direct rays of the sun. In addition, such a device would provide a sufficient amount of comfortable, diffuse illumination to replace artificially the waning light of the sky.

If a rocket airplane, coasting with dead engines, operates at extremely high altitudes, little or no force will be exerted on its occupants, since the aerodynamic forces of lift and drag gradually vanish in the aeropause. These mechanical conditions result in the partial or entire loss of weight on the part of the occupants. Following the reasoning of H. Haber,[21] it can be shown that weight of a body can be identified with the vectorial sum of all external forces acting on the body. In case of a coasting rocket airplane—i.e., in the absence of propelling forces—the only external forces acting on the craft are aerodynamic forces. From these deliberations it follows immediately that the craft and its occupants become weightless, as soon as lift and drag vanish. We then recognize that the coasting phase in the operation of aeropause vehicles will be attended by a novel factor of man's mechanical environment, namely, the phenomenon of weightlessness. The durations of weightlessness to be expected in future flights are given in the previously discussed Fig. 3, which is based on the assumption that the trajectory of the coasting craft is not disturbed by aerodynamic forces.

From the foregoing it follows that weightlessness will be a further factor of the environment in the aeropause to which man will be exposed for periods of time lasting between 4 to 6 min. Before experimental studies on the physiology of the weightless state were made, Gauer, H. Haber, and S. G. Gerathewohl[22–25] attempted to derive the theory of this problem. Later, experimental studies on animals in rockets (Henry et al.[26]) and on humans in the airplane, using the methods proposed by F. Haber and H. Haber,[27] were carried out. According to the latest of these studies made by von Beckh[28, 29] in Argentina, weightlessness results in marked disturbances in orientation, sensomotor functions, and muscular control. Von Beckh also observed a marked delay in the recovery from black-out caused by *g* forces, if the acceleration period is followed immediately by a transfer into the state of weightlessness. Repeated exposure to weightlessness lasting up to 30 sec. appears to result in some habituation to this state with the result that the disturbances mentioned above become less severe. Similar observations were made by Yeager (Air Force) and Crossfield (NACA) who made a series of zero-*g* flights in this country.

The experimental results on the effects of weightlessness obtained so far are based on a duration of this state lasting up to 30 sec. No immediate conclusion can be drawn as to its effects if the exposure is prolonged to durations of 4 to 6 min. The observations made during the short periods, however, indicate that weightlessness occurring during flights in the aeropause will demand the attention of the medical research workers in the field of aviation medicine and space medicine.

In order to succeed in operating our airplanes at ever increasing heights, we must replace artificially the many functions of the atmosphere which we leave behind. Inside his cockpit man must be supplied with clean breathing air of a suitably high pressure, he must be protected against ultraviolet radiation, and he must be supplied with illumination. For some time to come it will probably not be necessary to protect the pilot from cosmic radiation and meteorites, but merely because flights in the aeropause will last only a short time. Among all the factors of the environment in the aeropause, the mechanical factors occupy a unique position: during the coasting phase of his flight we cannot supply the pilot with an external force that preserves his weight.

The human problems of flight in the aeropause—which constitutes the frontiers of flight in the next future—will differ from today's problems only by degree. The only exception is weightlessness, which will be a novel experience for air crews. Barring any undue surprise in man's ability to live and perform under conditions of weightlessness, it appears that man will be ready to fly in the regions between atmosphere and space as soon as the engineer will furnish the machine that can do the same.

References

[1] Strughold, H., Haber, H., Buettner, K., and Haber, F., *Where Does Space Begin? Functional Concept of the Boundaries between Atmosphere and Space*, Journal of Aviation Medicine, Vol. 22, p. 342, 1951.

[2] Buettner, K. J. K., and Haber, H., *The Aeropause*, Science, Vol. 115, p. 656, 1952.

[3] *Physics and Medicine of the Upper Atmosphere; a Study of the Aeropause*, Ed. by S. C. White and O. O. Benson, Jr., University of New Mexico Press, Albuquerque, N.M., 1952.

[4] Haber, H., *The Mechanical Environment in the Future Aircraft*, contribution to *Frontiers of Man-Controlled Flight*, Ed. by H. Haber, Institute of Transportation and Traffic Engineering, University of California, 1953.

[5] Haber, F., *The Heat Barrier*, Scientific American, Vol. 188, No. 12, p. 80, December, 1953.

[6] Schaefer, H. J., *Evaluation of Present-Day Knowledge of Cosmic Radiation in Terms of Hazard to Health*, Journal of Aviation Medicine, Vol. 21, p. 375, 1950.

[7] Schaefer, H. J., *The Biologic Effects of Cosmic Radiation*, contribution to *Physics and Medicine of the Upper Atmosphere; a Study of the Aeropause*, Ed. by S. C. White and O. O. Benson, Jr., University of New Mexico Press, Albuquerque, N.M., 1952.

[8] Schaefer, H. J., *Theory of Protection of Man in the Region of the Primary Cosmic Radiation*, Project No. NM 001 059.13.06, U.S. Naval School of Aviation Medicine, U.S. Naval Air Station, Pensacola, Fla., August, 1953.

[9] Schaefer, H. J , *The Definition of a Permissible Dose for Heavy Nuclei of the Primary Cosmic Radiation*, Journal of Aviation Medicine, Vol. 25, p. 392, 1954.

[10] Tobias, C. A., *Radiation Hazards in High Altitude Aviation*, Journal of Aviation Medicine, Vol. 23, p. 345, 1952.

[11] Storer, J. B., Furchner, J. E., and Krebs, A. T., *Specific Ionization and Relative Biological Effectiveness of Ionizing Radiations in Mammalian Systems*, Journal of Aviation Medicine, Vol. 25, p. 368, 1954.

[12] Simons, D. G., *Methods and Results of One Year of Balloon Flights with Biological Specimens*, Journal of Aviation Medicine, Vol. 25, p. 380, 1954.

[13] Chase, H. B., *Cutaneous Effects of Primary Cosmic Radiation*, Journal of Aviation Medicine, Vol. 25, p. 388, 1954.

[14] Eugster, E., *Methods for Demonstrating the Biological Effectiveness of Cosmic Radiation at High Altitudes*, Journal of Aviation Medicine, Vol. 24, p. 222, 1953.

[15] Buettner, K. J. K., *Effects of Cosmic, Ultra-Violet and Heat Radiation at 50,000 to 100,000 Feet*, paper presented at the June, 1952, meeting of the Aero-Medical Engineering Association, University of California, Los Angeles.

[16] Tousey, R., and Hulburt, E. O., *Brightness and Polarization of the Daylight Sky at Various Altitudes Above Sea Level*, Journal of the Optical Society of America, Vol. 37, p. 78, 1947.

[17] Chappuis, M. J., *Sur les Spectres d'Absorption de l'Ozone et de l'Acide Pernitrique*, Journal de Physique, (2) 1, p. 484, 1882.

[18] Weaver, H. F., *The Visibility of Stars Without Optical Aid*, Publications of the Astronomical Society of the Pacific, 59, p. 232, 1947.

[19] Guth, S. K., *Brightness Relationships for Comfortable Seeing*, Journal of the Optical Society of America, Vol. 41, p. 235, 1951.

[20] Cibis, P. A., *A Discussion of Retinal Adaptation Applicable to Visual Problems Encountered by Man in Flight at Increasing Altitudes*, contribution to *Physics and Medicine of the Upper Atmosphere; a Study of the Aeropause*, Ed. by S. C. White and O. O. Benson, Jr., University of New Mexico Press, Albuquerque, N.M., 1952.

[21] Haber, H., *Gravity, Inertia, and Weight*, contribution to *Physics and Medicine of the Upper Atmosphere; a Study of the Aeropause*, Ed. by S. C. White and O. O. Benson, Jr., University of New Mexico Press, Albuquerque, N.M., 1952.

[22] Gauer, O., and Haber, H., *Man under Gravity-Free Conditions*, contribution to *German Aviation Medicine World War II*, Vol. 1, p. 641, U.S. Government Printing Office, Washington, D.C., 1950.

[23] Haber, H., *The Human Body in Space*, Scientific American, Vol. 185, No. 1, p. 16, January, 1951.

[24] Haber, H., and Gerathewohl, S. J., *Physics and Psychophysics of Weightlessness*, Journal of Aviation Medicine, Vol. 22, p. 180, 1951.

[25] Gerathewohl, S. J., *Physics and Psychophysics of Weightlessness—Visual Perceptions*, Journal of Aviation Medicine, Vol. 23, p. 373, 1952.

[26] Henry, J. P., Ballinger, E. R., Maher, P. J., and Simons, D. G., *Animal Studies of the Sub-gravity State during Rocket Flight*, Journal of Aviation Medicine, Vol. 23, p. 421, 1952.

[27] Haber, F., and Haber, H., *Possible Methods of Producing the Gravity-Free State for Medical Research*, Journal of Aviation Medicine, Vol. 21, p. 395, 1950.

[28] von Beckh, H. J. A., *Experiments with Animals and Human Subjects under Sub- and Zero-Gravity Conditions during the Dive and Parabolic Flight*, Journal of Aviation Medicine, Vol. 25, p. 235, 1954.

[29] Gerathewohl, S. J., *Comparative Studies on Animals and Human Subjects in the Gravity-Free State*, Journal of Aviation Medicine, Vol. 25, p. 412, 1954.

[30] Strughold, H., *Atmospheric Space Equivalence*, Journal of Aviation Medicine, Vol. 25, p. 420, 1954.

[31] Birge, A. C., *Laboratory Studies for Evaluating the Biological Effects of Primary Cosmic Radiation*, Journal of Aviation Medicine, Vol. 25, p. 326, 1954.

[32] Campbell, B., *A Biological Study of the Effects of the Heavy Particle Component of Cosmic Rays*, Journal of Aviation Medicine, Vol. 25, p. 361, 1954.

The Air Weapon Systems in Operation

(*Continued from page 45*)

(1) Technical data and a set of spares and spare parts for the weapon are phased to arrive at the combat base before the weapon arrives.

(2) Support equipment has been adequately planned, designed, produced, and phased to arrive before the weapon.

(3) Accessibility and ease in maintenance have been given their proper weight in designing and producing the weapon.

(4) The entire package is designed and built with full consideration of the combat crew, as well as the support and maintenance crews.

(5) The "low-level," "fast-moving" inventory objective is achieved with a "minimum turn-around time" between sorties.

We must discontinue the practice of designing aircraft that meet contract performance with apparently little regard to the fact that we must use and maintain them during a long service life. This practice costs us combat strength, man power, and money. If the original characteristics prepared by the Air Force and the original design philosophy used by the engineers would give full consideration to the fundamental problems of the Air Force tactical units, there would be, in the final pay off, the "maximum" number of "effective" combat sorties with "minimum investment" in men and materiel. This, in essence, is what we are after in our whole "weapon systems concept." I hope that industry will work with us to achieve more ton-miles per aircraft.

An aircraft on the ground is a liability in time of war. We want ours ready to go so we can win a war quickly and cheaply.

Fabrication Aspects of **Large Structural Components**

H. V. SCHWALENBERG*
North American Aviation, Inc.

Introduction

TODAY'S AIR-FRAME DESIGN follows a definite trend toward large, single-piece air-frame components fabricated from high-strength, lightweight alloys. This presentation will deal with manufacturing methods currently used in the fabrication and processing of a few typically large, single-piece components. The discussion will also cover the accomplishments and results obtained to date in this field, as experienced by North American Aviation in the manufacture of fighter-type aircraft. However, these same conditions and problems are also applicable to bomber-type aircraft, the size and configuration of the components involved differing only with the end product.

The advent of the jet-engine power plant, and its continued improvement, has led to a rapid advancement in aircraft design which has required the supporting development of new manufacturing techniques by every production department of an aircraft plant. These techniques include multicontouring, cavity and sculpture milling, taper machining, and routing of one-piece air-frame parts. Form die quench and prestressed hot forming operations are also newly developed techniques.

Air frames were formerly manufactured with thin skins, supported by substructures made up of many details of equally thin material, thus providing the lightest possible structure. This design concept has been rapidly replaced with the one-piece wing surfaces machined from materials 1 in. or more thick, integrally stiffened by ribs, pads, and lands. These skins, large forged ribs, beams, and other odd-shaped attached fittings are fast becoming standard components of modern, high-speed aircraft.

Each aircraft company has developed individual types of structures which have become heavier and larger with each succeeding model; the effect on metal removing and forming operations within the respective production departments resulting from this trend cannot be overemphasized. Known machining methods and techniques have been utilized to the fullest extent to meet these new requirements but have been inadequate in many cases. Larger standard machine tools, as well as new machines of radically differing design, along with new principles and techniques, have had to be developed. These techniques and machines are constantly being improved, the number of parts per assembly is being reduced, and methods more conducive to minimum cost and maximum producibility are being developed.

Illustrative of this trend is the increase from conventional wing weight of approximately 1,700 lbs. to the current F-100 wing weight of 3,000 lbs. Even though the wing is about 80 per cent heavier, "bits and pieces" have been practically eliminated. The speed transition from the World War II F-51 Mustang, with a top speed of 450 m.p.h., to the F-86 Sabre jet, rated at 650 m.p.h., has now been surpassed by the F-100 Super Sabre, which has exceeded the speed of sound in level flight—the first operational-type airplane to do so. This performance characteristic alone has dictated the change from the "bits and pieces" type of structure to the extensive use of large one-piece components.

We in the aircraft industry have recognized this trend toward large forgings in air-frame structure, the desirability of eliminating details, and the economic advantages that may be possible in increasing the size and quality of forged components. Therefore, the principal forms of such large, high-strength aluminum alloy parts considered in this presentation are die forgings, routed grids, and taper-milled or machine-sculptured plate.

Die Forgings

The considerable publicity that has been given to the heavy press program as sponsored by the Air Force causes most of us to think first of die forgings when the design specifies an unusually large structural element.

Four forging presses, two each of 35,000- and 50,000-ton capacity, are being constructed in the initial phase of this program. I was advised last April, by Mr. Zeitland of Hydro-Press, Inc., that the 35,000-ton press being erected at Wyman-Gordon will be completed in November of this year and the 50,000-ton press, also being installed at Wyman-Gordon, will be in production in February of 1955. Much has already been written about the potentialities of these presses in regard to possible web thicknesses, draft angles, fillet radii, minimum weight, net or precision forgings. However, from the standpoint of practical design criteria, all of this discussion must be considered to be purely theoretical. It will require at least a year of operation to determine the actual capabilities and limitations of the heavy press program.

Presented at the Aspects of Heavy Skin Construction Session, National Summer Meeting, IAS, Los Angeles, June 21–24, 1954.

* General Superintendent.

At this point, I should like to construct a hypothetical example to illustrate the potential economic advantages of these presses. The following figures could apply to aircraft placed in production within the last 2 years. Assuming a model contained 342 light alloy forgings, the average part would undergo 12 machining operations, amounting to 4.4 hours, for a total of 1,505 machining hours per plane. If precision forgings, as yet undeveloped, could have been used, they would have reduced this machining time by 25 per cent—a saving of 377 hours at $5.00 per hour, or $1,885 per airplane. This would amount to approximately $1,000,000 on a 500-plane contract.

The tremendous economies that may be realized by the use of precision forgings, therefore, make it a proper subject for speculation. It would be our considered recommendation to continue cavity milling on globs or neutral die forgings for finished parts identical to those for which precision forgings are ordered to ensure availability of schedule requirements during the initial operations of these large presses. The advance publicity that the program has received, however, should not blind the designer to other methods of producing large air-frame components.

Routed Grids

Grids are a comparatively recent development in air-frame structure. Stresswise, they provide for densification of surface structure to absorb and distribute concentrated loads. Sandwiched between skins to provide the necessary meat, their most common application is in outer-wing panels and in dive brake doors.

Grids used in outer-wing sections that have skins riveted upon both sides are cheaper to produce than wing-center-section grid panels, which have an integral skin upon one side. This saving is possible because, in routing grids for outer-wing panels, the complete removal of the material between the bars is an easier operation than partial removal of the material by sculpture milling, which requires close tolerance depth control. Also, since it is obviously necessary to rivet one skin for a sandwich cover assembly, it is N.A.A.'s experience that both skins may as well be riveted at the same time.

Our experience with grids has proved that routing produces a part of less weight than a die forging because of the elimination of draft and that closer tolerances can be maintained. In addition, the overall cost of a routed grid is from 10 to 25 per cent less than for a forging, exclusive of tooling. The cost ratio of tooling is approximately 1 for a routed grid to 10 for a forged grid. The first grid that was used on an N.A.A. air frame cost $550 when routed from plate to finished tolerances. A forging of the part would have required an investment of $30,000 in dies, and the forging would have cost $700 exclusive of finish machining.

A comparative cost analysis of grids versus extruded hat section stringers, straps, and doublers revealed that routing grids from plate stock was the most economical method of fabricating these components. This conclusion was based on savings in weight and the elimination of details and hidden costs, all of which were not possible by any other means.

Form-Die Quench Operation

The key to the successful contouring of routed grids as experienced by N.A.A. is the form-die quench process whereby the part is heat treated, contoured, and stress relieved in one continuous operation. In the initial phase of the form-die quench cycle, the part is placed in a heat-treat furnace and heated to a specified, closely controlled temperature. The part is held at that temperature until complete and even heating of the metal has been achieved. The heated part is then removed from the furnace and transferred as rapidly as possible to the lower member of a closely mated forming die anchored to the base of the press. The amount of temperature drop-off during the transfer is very critical and this operation demands teamwork and coordination. The upper die member, attached to the press platen, immediately descends and simultaneously forms and cools the part by metallic conduction through the relatively cold die surfaces. As the form dies constitute a large mass of metal, the die surfaces remain cool during a production run of parts made from thin-gage material. In form-die quenching heavy sections, dies are cooled by circulating water through cored out cavities below and through die surfaces. Residual stresses and spring back in the part are entirely eliminated, as form-die quenching stretches the metal in all directions in fine increments. At heat-treat temperature, the metal expands uniformly in all directions as the natural consequence of elevated temperature. A permanent stretch or deformation of the metal is achieved by subjecting the expanded metal to high forming pressures and maintaining pressures of equal magnitude throughout the forming operation. A short period at dwell prevents the metal from contracting while cooling. We have found it necessary to apply pressures in excess of 7,000 lbs. per sq.in. to restrict 1-in. thick material between the smooth surfaces of the Kirksite form dies. The per cent of stretch introduced in the metal by form-die quenching is proportional to the coefficient of thermal expansion of the alloy at the processing temperature. Therefore, when preparing the blank or routed part, it is necessary to reduce it in size from standard measure by approximately eleven thousandths per inch. This reduction can be accomplished by photographic method.

Taper-Milled or Machine-Sculptured Plate

With the advent of the F-86A Sabre jet in 1948 North American Aviation introduced their first machine-tapered and sculptured skins. The skepticism with which many designers and production men originally viewed these designs now seems to have been unwarranted. Taper milling and sculpturing of large

sheet was, at that time, a radical deviation from custom and was seriously questioned on the basis of expense. On the first Sabres there was a total of 12 of these machined skins. The prototype wing skins were vendor produced at a cost of $900 each. Since then this cost has progressively diminished to about $10 per part through increased know-how and machine and tooling refinement. Our latest standard machine time for 12 taper-milled skins on the F-86D model is 11 hours, or approximately $55 per air frame.

The operations involved in the manufacture of this type of machine-tapered and sculptured skin require the use of a converted large bed planer-mill. This conversion is accomplished by mounting vertically, on the cross rail of the mill, high-speed motors on swivel or universal saddles. These motors, ranging from 30 to 100 hp. and with spindle speeds up to 3,600 r.p.m., utilize fly-type, single-tooth cutters. For forward, straight-line, full-length taper milling, a cutter of 10-in. diameter is used. Table feeds range from 90 to 120 in. per min. However, 4-, 6-, or 8-in. diameter, single-tooth cutters are used at slower table and cross-rail feeds for the more complex milling around lands and islands. The material is held down by vacuum to a plate having compound sine features either spanwise or chordwise, or both. Finished sculpture-milled skins will vary in thickness from 0.250 in. to 0.040 in.

The mild contouring of tapered or sculptured skins used between spars of the wing box section can be easily accomplished on the hydraulic press brake, using a channel rubber die and a bull-nose punch.

The initial justification for taper milling lay, primarily, in the possible saving of weight in comparison to a build-up assembly. However, cost alone would now be sufficient justification. For example, the cost difference between dimpling a conventional sheet metal wing assembly or cut countersinking for rivets in a tapered and sculptured sheet is more than the present cost of the milling operation alone.

Machined, Integrally Stiffened or Ribbed Skins

The design evolution of a comparatively flat, tapered, and sculptured-milled skin into a deeply sculptured part containing integral ribs and stiffeners has been rapid. The latter form has now become a production reality. Costwise, these parts are expensive, but alternate designs either have not been feasible within the present wing configuration or have not been competitive structurally. Also, the best alternate build-up assembly design, even if it had been acceptable, would have been more expensive to fabricate in a production quantity than the sculptured skin, especially if secondary expenses had been included in the comparative cost estimate.

The machining of the integrally stiffened skin can be accomplished on the planer-mill type of machine with the high-speed motor mounted horizontally. The cutter width is usually $1^1/_2$ to 2 in. and of a diameter of 14 in. Two teeth, and a tooth load of approximately 0.015 at a feed rate of 100 in. per min., give a very satisfactory surface finish.

The machining of the converging rub sections that are on straight-line elements or percentage lines is accomplished by rotating the vacuum sine table about a predetermined pivot point to bring the trace of the rib in line with the table travel of the machine. Rise and fall of the head and cutter is dictated by follower systems in conjunction with profile bars fastened to the side of the table.

Another machine, radically different in design from the modified conventional planer-mill, was designed and built by North American Aviation. It is successfully producing integrally stiffened skins for wing panels and empennage for the F-100. This machine has been named the Beam Mill, and it is just what the name implies.

The principle of this machine is to position the beam in line with the desired pattern of the ribs. The motor that is mounted on the underside of the beam travels in relation to the position of the beam. The table or vacuum plate holding the workpiece remains stationary. This machine is also equipped with a follower, the profile bars being mounted on the side of the beam where they remain free of chips. Details of cutters, feed, speed, etc., are essentially the same as those mentioned before for the planer-mill type of machine.

The horizontal milling time expended to machine the prototype integrally stiffened skin for the F-100 amounted to 280 hours. This time was reduced to 38 hours during the initial production run after coordination and refinement of tooling had been accomplished. At this reading, we can reasonably expect a further reduction in hours for this operation to something in the neighborhood of 10 to 14 hours.

The contouring of these particular parts presented a problem. You may ask the most obvious question, "Why not form-die quench?" You will recall that the pressure requirement for restricting a plate of 1-in. average thickness was 7,000 lbs. per sq.in. The skins making up the box section of the wing on the F-100 are 240 in. long, with a mean width of 40 in. A press of a 33,600-ton capacity would be required to do the job by the form-die quench method.

Another consideration that put the form-die quench process out of contention for these particular parts was the cost of the dies required. I think I mentioned previously, when discussing form-die quenching of grids, the necessity for closely matched tooling. Our Production Development Lab has determined that die contact with part of less than 92 per cent-could not be tolerated.

Prestressed Hot Forming

As stated earlier, for slight or moderate contouring of large sculptured and integrally stiffened parts like those of the wing-box-section skins, the form-die quench method of forming is not applicable because of the size of the equipment that would be required,

plus what is regarded as an impossible tooling and machining job. "Shot-peening" is applicable to some parts but is not effective on heavy pads or attaching sections that may be 1 in. or more thick. The prestressed hot forming process has shown considerable success in forming large integrally stiffened wing panels with heavy root sections.

The desired contour results from the yielding of the material at elevated temperature induced by being restrained in overformed condition while heated to a temperature in the precipitation aging range for aluminum alloys. The part on the fixture in the overcontoured condition is placed in an oven. Program controllers are used to control the temperature in the furnace at the heavy and light ends of the part to bring them up to the soaking temperature as rapidly as possible, yet have both arrive at the soaking temperature at the same time. A soaking period of $1^1/_2$ hours at 270°, plus or minus 5°, is normally used. The fixture with part is then rolled out of the oven into the quenching position, and water is immediately sprayed onto the fixture and concave side of the part. The quenching rapidly cools the part and fixture for handling and limits the time at elevated temperature of the part.

An exaggeration of approximately 8 times the desired contour is required for prestressed hot forming present production parts. Any warpage of the part due to machining *influences* the results obtained from prestressed hot forming. However, this may be compensated for by the length of time the stressed part is held at temperature. This control will come from the experience of observant personnel with the process.

A larger wing skin, requiring more contour than the one discussed previously, is handled as follows: The fixture is made in two halves that are assembled with the part horizontal and then set on a track with part vertical for rolling into furnace. Load couples are attached to the part as discussed previously. After a heating cycle of 2 hours, plus a soak time of $1^1/_2$ hours, the fixture with part is rolled out of the furnace and spray quenched. Integrally stiffened sculptured skins $1^1/_4$ to $1^7/_8$ in. thick, and as large as 100 by 210 in. in maximum dimensions, are being formed in production by this process.

Some difficulty is encountered with the inconsistency of the metal in the heavy raw plate stock required for today's aircraft. It is expected that closer cooperation between the aircraft industry and the metals industry will eventually result in the elimination of most of the flaws in material currently being produced. This will bring the material up to the high specifications and close tolerances demanded by today's finished product.

Our experience to date has convinced us that various other methods of preparing large integral wing skins or similar parts, such as casting, forging, rolling, and extruding, cannot compete with the machine-sculptured type of structure for all-around efficiency. At the same time, the extensive use of this type of structure should be approached with caution where large production quotas are required, as availability of machine time must always be taken into consideration. The machine time and subsequent cost are factors whose importance can be expected to increase as new models are conceived. It would be only logical to assume that the increase in size, speed, and gross weight of projected aircraft would certainly require larger, heavier, and perhaps more complex integral structures than those confronting us at the present time.

Future unknown problems, combined with present problems we have not as yet completely solved, point to the necessity for a vast field of exploration and development if we hope to maintain a pace in production equal to the progress of modern design. However, it should always be borne in mind that production is not merely a miracle to be accomplished by manufacturing, but something that must actually be designed into the airplane.

Magamps Applied to Aircraft Control Problems

(*Continued from page 49*)

eters have been obtained on the components for a valid analytical study.

Future air-borne applications of magnetic amplifiers will depend not only upon their proved reliability but also upon two other factors:

(1) The continued reduction of their time constants and, therefore, the opening of new areas of application.

(2) How well their performance can be predicted and controlled in production and, therefore, relied upon for initial systems planning studies.

In conclusion it can be said that, with regard to the first factor, the development trends of today indicate that amplifiers having both a "time constant" and a "dead time" will gradually be replaced by amplifiers that have only a "dead time." (See items 4 through 7 in Table 1.) The magnitude of this "dead time" can be reduced further by an increase in the frequency of the supply voltage. The solution to the second factor is at hand through the use of statistical methods in quality control and manufacture and the methods of representing magnetic amplifier operation in feedback control systems by means of transfer functions, as outlined in this paper.

The Growing Interest in Space Travel

A Report on the

Fifth International Astronautical Congress, Innsbruck, Austria, August 1–7, 1954

THIRTY YEARS AGO at a meeting of the Deutsche Naturforscher- und Arztetag in Innsbruck, Prof. Hermann Oberth discussed the possibility of space travel and the technical problems as he saw them amid the laughter of his scientific colleagues, who believed that escape of a vehicle from the earth was an idle dream. This year in the same city there was held the Fifth International Astronautical Congress at which Professor Oberth presented a paper on the design of pressure suits for use in free space. This time the astronautical pioneer was heard with respect.

In the 30-year period there have been many scientific and technical developments that have advanced the dream of space travel to a vision whose realization seems nearer if not immediately at hand. The program of the Congress itself is the best illustration of the change in attitude of at least some scientists. Visiting aeronautical engineers were surprised to find many papers dealing with problems of immediate interest to them.

Thirty-two papers were read by contributors: eight from the United States; seven from Germany; four from Austria; two each from Great Britain, France, Holland, Egypt, and Argentina; and one each from Canada, Italy, and Switzerland. Fourteen of the papers were wholly astronautical in character, while eighteen dealt with problems that are now or will in the near future be of concern in airplanes and guided missiles. Printed preprints of twenty, mimeographed texts of four, and abstracts of three of the papers were available at the meeting.

Of the wholly astronautical papers, two dealt with analysis of orbital systems and methods of proceeding from an orbit around the earth to an orbit around a planet, one with the automatic steering of step rockets in space, one with analog computations of satellite orbits, one with the thermal dissipation of meteorites by bumper screens, one, already referred to, with the design of space suits, and two with ionic propulsion of space vehicles in regions distant from gravitational fields. The use of ions as a working medium for rockets was shown to be economical in fuel, but the realizable thrusts are small. Nevertheless, accelerations of several orders of 10 lower than gravity at the earth's surface (4×10^{-5}) give large velocities and distances in free space when continued over long periods (10 km. per sec. and 10^8 km. at the end of 1 year for a 250-ton ship).

Six of the astronautical papers were of miscellaneous character. F. I. Ordway, a United States student at the University of Paris, formerly with Reaction Motors, Inc., spoke on "The Respectability of Astronautics as Reflected by Recent Developments in the United States," the paper being prepared in collaboration with H. E. Canney, Jr., of Bell Aircraft Corporation. I. M. Levitt, Director of the Fels Planetarium, Philadelphia, discussed the geodetic significance of a minimum satellite vehicle. A paper prepared by A. J. Zähringer on solid propellants and astronautics was read. Other papers dealt with the legal problems of free space, ideographs suitable for communication with inhabitants of other planets, and possible activities of the International Astronautical Federation. Probably aeronautical engineers will find little of direct interest to their work in these purely astronautical papers.

The remaining 18 papers are of substantially different character. Seven of them dealt with rocket trajectories. H. J. Käppler and M. E. Kübler discussed the return of winged vehicles from outer space stations. Much of this paper dealt with effects of air resistance at very high altitudes on satellite vehicles and with reentry trajectories. There was no experimental material, and the assumptions were relatively crude. The object was a general view of the problem.

Other papers treated the calculation of step rockets, optimal programing of rocket thrust direction, measurement of rocket trajectories, the French program for exploration of the upper atmosphere by the rocket "Veronica" during the International Geophysical Year, and approximate computations of the aerodynamic heating of conical bodies at extremely high Mach Numbers.

Four papers on combustion were presented. F. Cap of Innsbruck formulated the theoretical equations for flows in which combustion occurs and outlined methods for their solution. U. T. Bödewalt, of Egypt, discussed

Left to right: **Prof. Dr. Friedrich Hecht, President, Austrian Astronautical Society, and Prof. Hermann Oberth, Pioneer Astronautical Scientist.**

Left to right: Ing. Josef Stemmer, Secretary, International Astronautical Federation; Darrel C. Romick, Goodyear Aircraft Corporation; and Frederick C. Durant III, President, International Astronautical Federation.

the influence of recombination on the efficiency of liquid-fuel rockets. A paper was read for E. Sänger on stationary nuclear combustion in rockets and one for Irene Sänger-Bredt on the investigation of initial steps in combustion processes. Unfortunately both authors were prevented from attending by the official opening under E. Sänger's direction of an Institute for Physics of Jet Propulsion at Stuttgart. The paper by I. Sänger-Bredt was particularly stimulating. It contrasted nuclear production of heat in which the laws of the macroscopic processes were derived from knowledge of the interactions between individual nuclei and chemical combustion in which the elementary reactions are not understood physically. The author proposes that the technique of crossed molecular beams *in vacuo* be applied to study the elementary processes. Her paper reviewed presently available experimental methods for studying combustion processes and some of the past work on molecular beams.

A paper by H. H. Kolle of Stuttgart described computations of the influence of turbopump design on the flight performance of large rockets.

Two papers dealt with cosmic ray hazards, one by H. J. Schaefer of the U. S. Naval School of Aviation Medicine and one by J. Eugster of Berne. Eugster described a technique of exposing a sample of tissue to cosmic rays in the stratosphere and reinstalling the tissue in the living organism to follow changes in cell structure in its natural environment.

There were two contributions on high-temperature materials. One was by R. Kieffer and F. Benesovsky of the Metallwerke Plansee, Reutte, Tyrol, a leading exponent of powder metallurgy techniques on high-temperature sintered materials. The paper described some of the company's WZ alloys, alloys of Ti, C, Ni, Cr, and Co. It also referred to experimental work on $MoSi_2$, pieces of which have been heated up to 1,700°C. without scaling; but the material is too brittle for turbine blades. The second paper, by E. Fitzer of Vienna, was a summary-type paper on the development of high-temperature materials. The paper described a recent development by the author of a protective coating for Mo and W. It depends on the production of a surface layer of $MoSi_2$ by the catalytic reduction of silica chloride by hydrogen (Austrian Patent 178779). Protection for 300 hours at 1,600°C. has been obtained.

A paper by H. Strughold pointed out that many of the physiological problems to be encountered in space travel were already encountered in stratospheric flight, such as gravity-free trajectories, cosmic rays, low pressure, etc. The final paper by the pioneer astronaut, G. von Picquet, dealt with nomenclature questions for step rockets.

The Congress was held under the sponsorship of the International Astronautical Federation, a federation of astronautical, interplanetary, and rocket societies in 18 countries: Argentina, Austria, Denmark, France, Germany, Great Britain, Italy, Yugoslavia, Netherlands, Norway, South Africa, Spain, Sweden, Switzerland, United States, and, represented for the first time at this meeting, Egypt, Japan, and Brazil. Member societies from the United States are the American Rocket Society, Chicago Rocket Society, Detroit Rocket Society, Pacific Rocket Society, Reaction Research Society, and Philadelphia Astronautical Society. The official United States delegation was headed by Andrew G. Haley, President of the American Rocket Society.

At the business meeting of the Federation, Frederick C. Durant (United States) was re-elected president, and Joseph Stemmer (Switzerland) was re-elected secretary. E. Bush-Anderson (Denmark) was elected first vice-president, and Teofilo Tabanera (Argentina) second vice-president.

It was decided to establish a new publication, *Acta Astronautica*, under the sponsorship of the Federation. The publisher will be Springer.

The Sixth Astronautical Congress will be held in Copenhagen, Denmark, July 21–27, 1955.

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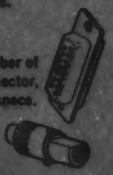
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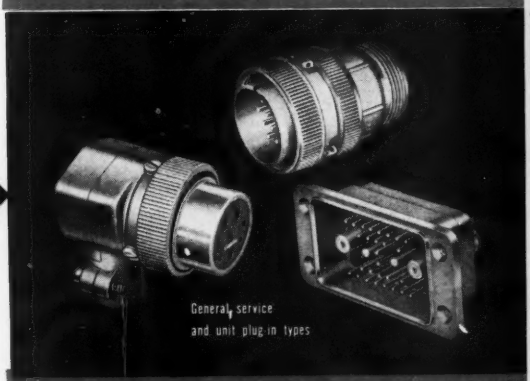
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IAS News

(*Continued from page 35*)

"fastest plane in the world" and which set an altitude record of 29,000 ft.; in 1930, he supervised the engineering of the Boeing 247, which incorporated the new low-wing cantilever construction and retractable landing gear; and, in 1933, he directed the development of the B-17 Flying Fortress.

In 1941, he became President and General Manager of the Pesco Products Division of Borg-Warner Corporation. In May of this year, he was named Chairman of the Supervisory Board and Director of Research and Development for the division. He resigned from these posts last August 15.

Mr. Minshall received the Wright Brothers Medal for outstanding contributions to commercial aviation and the Musick Memorial Trophy for his contribution to the safety of air travel.

Mr. Minshall is survived by his widow, Mrs. Margaret Minshall, and two daughters, Mary and Dorothy.

News of Members

▸ **Colonel Robert J. Benford,** USAF (MC) (AF), Editor, *U.S. Armed Forces Medical Journal*, was the U.S. Department of Defense representative at the World Medical Association's Fifth International Medical Journalism Meeting, held September 30 in Rome, Italy. Nine days before this, in Zurich, Switzerland, Colonel Benford presented a paper on "The Development and Growth of Aviation Medical Literature" at the Third Annual Meeting of the Aero Medical Association's French-Speaking Branch.

▸ **Christopher Clarkson** (AF), Aviation Representative, has been appointed representative of Vickers-Armstrongs, Limited, in the United States. Mr. Clarkson now maintains his offices at 10 Rockefeller Plaza, New York.

▸ **Rear Admiral Luis de Florez,** USN (Ret.) (F), Chairman of the Board, The de Florez Company, Inc., has been elected to the Board of Directors of Pioneer Parachute Company, Inc.

▸ **Frederick F. Fennema** (M), Operations Analyst, Headquarters Strategic Air Command, has been awarded the Air Force Decoration for Exceptional Civilian Service. This honor was accorded to Mr. Fennema for his performance of duty while serving as Operations Analyst for Headquarters Far East Air Forces Bomber Command from January to March, 1953.

▸ **William D. Greenfield** (TM), a University of Illinois graduate who recently completed an active tour of duty with the U.S. Navy, has been awarded the $2,000 Hiller Helicopter Fellowship for 1954–1955. Mr. Greenfield was selected to receive this Fellowship at Stanford University by that institution's Division of Aeronautics Committee. The Fellowship was established by Hiller Helicopters in 1953 as an annual award "to assist an outstanding student in research and study directed toward improvement of rotary-wing aircraft design."

▸ **Arthur E. Raymond** (HF), Vice-President—Engineering, Douglas Aircraft Company, Inc., has been named to receive the Spirit of St. Louis Medal. This award, which is administered by the Board of Honors of The American Society of Mechanical Engineers, is given every 3 years for meritorious service in the advancement of aeronautics. The Spirit of St. Louis Medal, established in 1929 by the citizens of St. Louis, Mo., will be conferred upon Mr. Raymond at the ASME's annual meeting in New York from November 29 to December 3.

▸ **Paul A. Smith** (AF), retired from the Coast and Geodetic Survey, U.S. Department of Commerce, on last August 31 after 30 years with this bureau. Immediately prior to his retirement, he was on special assignment with the Assistant Secretary of Defense for Research and Development. One of the leaders in establishing the International Civil Aviation Organization, Mr. Smith held various important posts in the ICAO over a 9-year period.

▸ **Gill Robb Wilson** (M), Editor, *Flying* Magazine, was awarded the Hoyt S. Vandenberg Memorial Trophy by the Air Force Association. Mr. Wilson was cited "for distinguished service contributing to national security and world peace through his efforts in behalf of airpower." The AFA stated that he has "labored unceasingly to educate America to the implications of the Air Age."

Members on the Move

The purpose of this section is to provide information concerning the latest affiliations of IAS members. All members, therefore, are urged to notify the News Editor of changes as soon as they occur.

H. Norman Abramson (TM), Associate Professor of Aeronautical Engineering and Associate Research Engineer, Agricultural and Mechanical College of Texas and Texas Engineering Experimental Station. Formerly, Acting Associate Professor of Aeronautical Engineering, Texas A. & M.

Vito D. Agosta (TM), Associate Professor, Mechanical Engineering, Polytechnic Institute of Brooklyn. Formerly, Assistant Professor, Mechanical Engineering, Brooklyn Polytechnic.

Lieutenant William F. Bakemeyer, USAF (TM), with Wright Air Development Center, Wright-Patterson AFB, Ohio. Formerly, Aerophysics Engineer, Convair-Fort Worth Division of General Dynamics Corporation.

Dr. Donald L. Benedict (M), Director of Physical Sciences Research, Stanford Research Institute. Formerly, Assistant Director, Engineering Division, Stanford Research Institute.

Dalton R. Buckingham (TM), Designer Aircraft—Hydraulic Systems, A. V. Roe Canada Limited. Formerly, Engineer, Mechanical Controls Section, Canadair, Ltd.

Dr. Chieh-Chien Chang (AF), Professor of Fluid Mechanics, Institute of Technology, University of Minnesota. Formerly, Research Professor, Institute for Fluid Dynamics and Applied Mathematics, University of Maryland.

Franklyn B. Cole, Jr. (M), Manager, Mechanical Research Department, Lockheed Aircraft Corporation. Formerly, Research Group Engineer—Controls, Lockheed.

Charles E. Craven (M), Liaison Engineer, Douglas Aircraft Company, Inc., Tulsa, Okla. Formerly, on Extended Active Duty, Lieutenant Commander, U.S. Navy.

William M. Duke (AF), Associate Director, Cornell Aeronautical Laboratory, Inc. Formerly, Assistant Director—Technical, Cornell Aeronautical Laboratory.

William H. Enders (TM), Research and Development Engineer, Aeronca Manufacturing Corporation. Formerly, First Lieutenant, USAF, Weapon System Engineer, Wright Air Development Center, Wright-Patterson AFB, Ohio.

Walter M. Fitch (M), now Editor-in-Chief, Research Engineering Activity (Methods) Reports, Wichita Division, Boeing Airplane Company.

Jack B. Gearhart (M), Senior Project Engineer, Radioplane Company, Subsidiary of Northrop Aircraft, Inc. Formerly, Chief Test Engineer, Company Project, Radioplane.

Donald P. Germeraad (AF), Chief Engineering Test Pilot, Convair-San Diego Division of General Dynamics Corporation. Formerly, Engineering Test Pilot, Convair.

PRECISION . . . born of skill and experience!

Flying a modern jet with its mighty power, lightning speed and high maneuverability is no job for a layman! Such precision flying requires a skilled hand and hundreds of hours of experience. But the skill and experience go deeper! Today's jet aircraft require precision parts—like bearings—to stand tremendous speeds and high temperatures. ☆ Bower aircraft bearings—first choice of leading jet engine manufacturers—are built to stand turbine speeds as high as 15,000 RPM and temperatures as high as 600° F. with a minimum of lubrication. Bower's many years' experience, matchless skill and consistent emphasis on quality give the aircraft industry bearings held to tolerances measured in millionths of an inch. ☆ An experienced Bower engineer will be glad to show you how Bower bearings can improve your product's performance. Get in touch with Bower soon.

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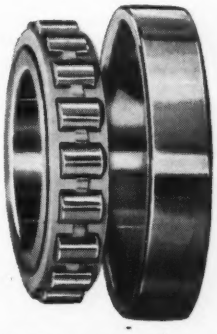


A COMPLETE LINE OF TAPERED, STRAIGHT AND JOURNAL ROLLER BEARINGS

BOWER

ROLLER BEARINGS

Captain Truman L. Griswold, USAF (TM), with Design Criteria Unit, Structures Branch, Aircraft Laboratory, Wright Air Development Center, Wright-Patterson AFB, Ohio. Formerly, Air Support Officer, Dugway Proving Ground, Tooele, Utah.

T. J. Harris (M), Director—Power Plant Engineering, Overhaul and Supply Depot, American Airlines, Inc., Tulsa, Okla. Formerly, Development Engineer—Power Plants, American Airlines, LaGuardia Airport, New York.

Harold V. Hawkins (AF), Assistant Director, Cook Research Laboratories Division, Cook Electric Company. Formerly, Director—Engineering, Aircraft Division, Globe Corporation.

Joseph Kempner (M), Associate Professor, Aeronautical Engineering, Polytechnic Institute of Brooklyn. Formerly, Assistant Professor, Aeronautical Engineering, Brooklyn Polytechnic.

Kenneth A. J. Knell (M), Technical Assistant to Principal Director of Research and Development (Aircraft), Ministry of Supply, England. Formerly, U.S. West Coast Representative, British Joint Services Mission, British Ministry of Supply.

Dr. Wayne E. Kuhn (M), General Manager, Research and Technical Department, The Texas Company. Formerly, Manager, Technical and Research Division, The Texas Company.

Harold Luskin (AF), Assistant Chief of Aerodynamics, Santa Monica Division, Douglas Aircraft Company, Inc. Formerly, Assistant Supervisor—Aerodynamics for Research, Santa Monica Division, Douglas.

Michael Maletz (M), Technical Specialist, Aerojet-General Corporation, Subsidiary of The General Tire and Rubber Company. Formerly, Design Specialist "A," Research and Development Laboratory, Aircraft Division, Rheem Manufacturing Company.

Thomas B. Knox, MIAS, has been named Assistant Departmental Head, Technical Services Department, Silver Spring (Md.) Laboratory, Vitro Corporation of America. Mr. Knox, who has been with Vitro since 1949, is a graduate of Massachusetts Institute of Technology where he received a degree in aeronautical engineering.

Monroe A. Maller (M), Assistant Regional Manager, Northeastern Region, Aeronautical Division, Minneapolis-Honeywell Regulator Company. Formerly, Senior Sales Engineer, Aeronautical Division, Minneapolis-Honeywell.

Luciano L. Mazzola (TM), Research Engineer, Department of Aeronautical Engineering, Massachusetts Institute of Technology. Formerly, Flight Research Engineer, Sikorsky Aircraft Division, United Aircraft Corporation.

Sebastian V. Nardo (TM), Associate Professor, Aeronautical Engineering, Polytechnic Institute of Brooklyn. Formerly, Assistant Professor, Aeronautical Engineering, Brooklyn Polytechnic.

Captain John Prodan, USAF (TM), Chief, Test Unit, MX-904 Section, Holloman Air Development Center, Holloman AFB, N.M. Formerly, Graduate Student, Guided Missile Program, University of Michigan.

Richard S. Purinton (M), Defense Products Manager, Harris-Seybold Company. Formerly, Director of Application Engineering, Air-Maze Corporation.

William J. Rainbird (M), Lecturer in Experimental Aerodynamics, College of Aeronautics, Cranfield, England. Formerly, with School of Engineering, Canterbury University College, New Zealand.

Duane E. Randall (TM), with Engineering Department, Pratt & Whitney Aircraft Division, United Aircraft Corporation. Formerly, First Lieutenant, USAF, Aircraft Maintenance Officer, 50th Maintenance Squadron, Clovis AFB, N.M.

Dr. James F. Reagan (M), Head, Missiles and Drones Division, Beech Aircraft Corporation. Formerly, Chief Engineer, Radioplane Company, Subsidiary of Northrop Aircraft, Inc.

Donald K. Robertson (M), Design Engineer I, The Glenn L. Martin Company. Formerly, Group Engineer—Vibration Analysis, Martin.

James M. Robertson (M), Professor of Theoretical and Applied Mechanics, Department of Theoretical and Applied Mechanics, College of Engineering, University of Illinois, Urbana, Ill. Formerly, Professor of Engineering Research and Assistant Director, Ordnance Research Laboratory, School of Engineering, The Pennsylvania State University.

Dr. Bernhard A. Rose (M), Manager, Physics Research Department, Lockheed Aircraft Corporation. Formerly, Manager, Mechanical Research Department, Lockheed.

Ira G. Ross (M), Director, Cornell Aeronautical Laboratory, Inc. Formerly, Head, Wind Tunnel Department, Cornell Aeronautical Laboratory.

Raymond I. Schneyer (M), Project Engineer, Design and Development of Gas Turbine Laboratory, Fairchild Engine Division, Fairchild Engine and Airplane Corporation. Formerly, Assistant Chief, Gas Dynamics Facilities, ARO, Inc., Arnold Engineering Development Center, Tullahoma, Tenn.

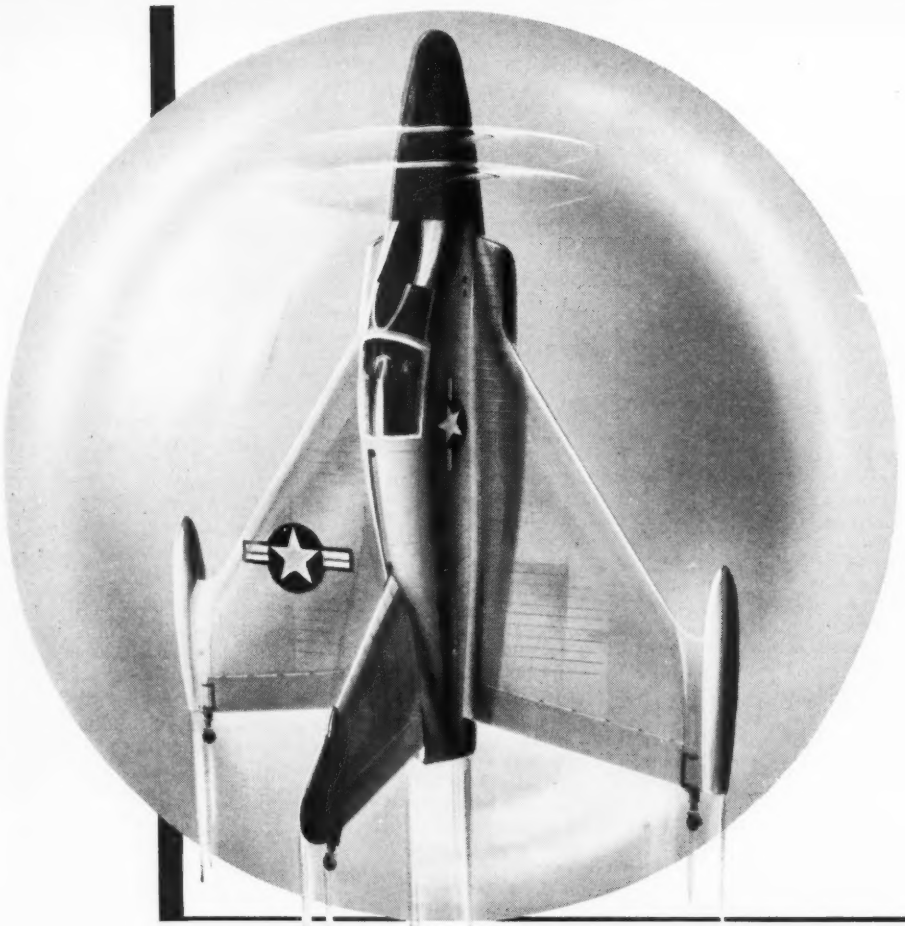
Harold K. Skramstad (AF), with National Bureau of Standards, Washington, D.C. Formerly, Assistant Chief, Missile Development Division, Corona Laboratories, National Bureau of Standards, Corona, Calif.

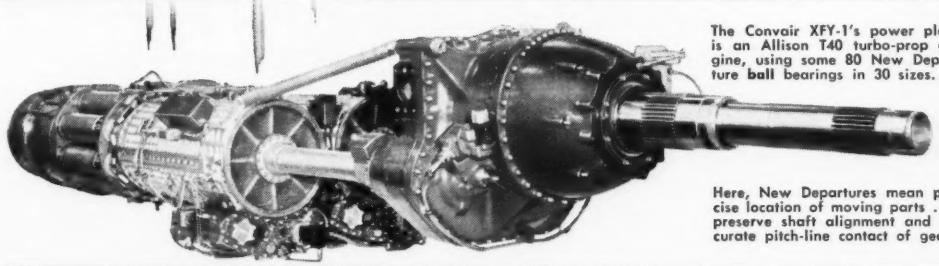
Earl M. Uram (TM), with Research Department, United Aircraft Corporation. Formerly, Research in Aerodynamics and Combustion, Harvard University.

Howard C. Walch (M), Project Engineer, Gas Turbine Division, Studebaker-

Dr. Louis G. Dunn, FIAS, has joined The Ramo-Wooldridge Corporation as Associate Director of the Guided Missile Research Division. Dr. Dunn recently announced his resignation as Director of the Jet Propulsion Laboratory, California Institute of Technology, a position that he had held since 1947.

Shukry K. Ibrahim, MIAS, Assistant Professor, Aeronautical Department, Cairo University, Egypt, was awarded a Fulbright Travel Grant and, for a 1-year period, is a Research Associate in the Department of Aeronautical Engineering, Institute of Technology, University of Minnesota. During his stay at Minnesota, Mr. Ibrahim is also collecting technical and trade information relative to aerodynamic and structural testing equipment which may be of use in planning aeronautical laboratories at Cairo University.





The Convair XFY-1's power plant is an Allison T40 turbo-prop engine, using some 80 New Departure **ball** bearings in 30 sizes.

Here, New Departures mean precise location of moving parts . . . preserve shaft alignment and accurate pitch-line contact of gears.

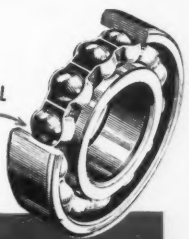
BEARINGS for a "Pogo" Pilot

Vertical take-off! Tailfirst landing! Fighter action! It's the Navy's newest—the Convair XFY-1 "pogo stick."

In its Allison T40 turbo-prop engine, some 80 New Departure **ball** bearings assure positive positioning of moving parts. And in the hub mechanisms of the Curtiss-Wright Turbolectric propellers, New Departures carry heavy loads.

Throughout defense and industry, you'll find New Departure **ball** bearings ideal for countless applications. So whatever your bearing problem, *talk with your New Departure engineer . . . now!*

NOTHING ROLLS LIKE A BALL



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In Canada: McKinnon Industries, Ltd., St. Catharines, Ontario

Packard Corporation. Formerly, Engineer I, Sverdrup & Parcel, Inc.

Bernard H. Wallach (M), Staff Engineer, Kearfott Company, Inc. Formerly, Project Engineer, First Class, Kearfott.

Norman C. Witbeck (M), with Development Engineering and Handling Special-Purpose Aircraft Power-Plant Projects, Fairchild Engine Division, Fairchild Engine and Airplane Corporation. Formerly, Executive Director, Panel on Aircraft Propulsion, Research and Development Board, Washington, D.C.

Eugene F. Wyszpolski (M), Assistant Chief Engineer, USN, BuAer General Representative—Western District. Formerly, Aeronautical Engineer, USN, BuAer Representative—Pasadena, Calif.

Dr. Shao Wen Yuan (AF), Research Professor, Department of Aeronautics, Polytechnic Institute of Brooklyn. Formerly, Associate Professor, Brooklyn Polytechnic.

Corporate Member News

• **Aerojet-General Corporation, Subsidiary of The General Tire & Rubber Company...**A thrust reverser for jet planes, developed in France by SNECMA, will be manufactured in the United States by Aerojet-General. The corporation states that this Aerojet-SNECMA thrust reverser provides up to 50 per cent reversed thrust almost instantly, cutting the ground roll in half. This unit retracts completely when not in use, thus causing no loss in normal thrust....A Southwest Regional Office has been established by Aerojet-General at 1000 Dragon St., Dallas. This address is also the Dallas headquarters for The General Tire & Rubber Company.

• **Air Associates, Inc....**An International Division has been formed to handle the corporation's export sales.

• **Aluminum Company of America...**A major plant expansion involving about $4,000,000 is under way at Alcoa's Vernon, Calif., works. The expansion program includes the construction of buildings with a combined floor area of 72,000 sq.ft. This area will house two large hydraulic forging presses, auxiliary equipment, and dies. The presses are of 8,000- and 1,500-ton capacities. The 8,000-ton press is expected to be in operation by the fall of 1955, while the 1,500-ton press is scheduled to be in production in early 1955. This new forging plant is intended to meet the need of the West Coast aircraft industry for heavy-press facilities in the Vernon area.

• **Bendix Aviation Corporation...**The LPA-70A flush-mounted loop antenna, for use with the ADF system, was expected to be in production last month at the Bendix Radio Division. The new Bendix ADF-70A receiver, designed for mounting in a $\frac{1}{2}$ ATR package, will be available next spring.

• **Boeing Airplane Company...**The Air Force announced last September that a portable air compressor, designed and manufactured by Boeing, had passed an official 200-hour USAF qualification run and was qualified to start large turbojet engines and to test aircraft pneumatic systems. Powered by a Boeing 502-series gas-turbine engine, this centrifugal-type compressor turns out 140 air hp. as a single-engined unit or 90 lbs. per min. of air at an absolute pressure of 53 lbs. per sq.in. and a temperature of 425°F. This portable air compressor, designated the Boeing 502-7D, is basically the same as the compressors used to start the engines of the B-52 Stratofortresses during $2\frac{1}{2}$ years of testing. The compressor is made as single- or twin-engined units enclosed in weatherproof cubicles. A later model air compressor, the 502-11, is being used in support of the Boeing 707 flight-test program. This compressor produces 180 air hp. or a flow of 120 lbs. of air per min. at 51.3 lbs. per sq.in. and 420°F. A further model, based on the Boeing Model 502-10 gas-turbine engine, is well along in development. It will produce 210 air hp. or an airflow of 141 lbs. per min. at temperature and pressure equal to that of the 502-11. This latest air compressor will be designated the Model 502-11B....The B-47E and RB-47E aircraft are now being equipped with General Electric J47-GE-25 engines, capable of 6,000 lbs. of thrust each. These six-jet medium bombers are coming off the production lines at the Boeing plant in Wichita, Kan., the Douglas Aircraft Company, Inc., plant at Tulsa, Okla., and the Lockheed Aircraft Corporation plant at Marietta, Ga....The pilotless-aircraft laboratory at Boeing's Plant II is now being enlarged by approximately 17,000 sq.ft. of floor space. This new addition will bring to about 48,000 sq.ft. the total area available for test and development work.

• **The Cessna Aircraft Company...**The T-37A twin-jet aircraft has been ordered into production by the U.S. Air Force. This trainer features a side-by-side configuration. The first flight of the number-one flying prototype T-37A was slated for late summer or early fall....Plans for a four-engined fully pressurized all-weather airplane for business executive use are now well under way. The prototype is scheduled to fly early in 1955. Designated the Cessna 620, this 8- to 10-place transport aircraft will be powered by 320-hp. GSO-526 engines, built by Continental Motors Corporation. The Cessna 620 will have an operational altitude of over 18,000 ft. and will be capable of 250 m.p.h. It will carry more than 400 gal. in wing-tip tanks and in the outer wing panels in bladder-type fuel cells.

• **Convair Division of General Dynamics Corporation...**The U.S. Navy announced recently that the Convair YF2Y-1 Sea Dart has exceeded the speed of sound in a shallow dive from 34,000 ft. This water-based aircraft is the second of the Sea Dart series to undergo flight tests. It is equipped with two Westinghouse J-46 engines. The first model of the Sea Dart, equipped with Westinghouse J-34 engines, made its maiden flight on April 9, 1953.... The first production model of USAF GRB-36 aircraft has been test flown at Convair-Fort Worth. The GRB-36 is an RB-36 reconnaissance bomber that has been modified to launch and retrieve a Republic RF-84 reconnaissance fighter while in flight....A new commercial transport, known as the Convair Freighter, has been announced. A cargo version of the Model 340 Convair-Liner, this aircraft is designed to haul up to 15,000 lbs. of cargo over medium air-line ranges at a cruising speed of 280 m.p.h. The top speed for the Freighter will be 313 m.p.h. A 10- by 6-ft. hydraulically operated cargo door, hinged

Shown during one of its test flights is the CH-1 helicopter, designed by the Helicopter Division of The Cessna Aircraft Company. Work on this helicopter was begun in the summer of 1952, and the first flight was made in July of 1953. It has recently been undergoing CAA certification tests. The CH-1, which has a rotor 35 ft. in diameter, is being certified, the company states, for a gross operating weight of 3,000 lbs. Cessna's new helicopter is powered by an FSO-470 fan-cooled supercharged engine, manufactured by Continental Motors Corporation.

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The unsatisfied demand for a rugged, dependable connector capable of meeting the exacting requirements of modern aircraft led the Scintilla Division of Bendix* to develop the *first* vibration-resistant electrical connector. These connectors using the revolutionary new insert material known as Scinflex were first used on Scintilla Division's ignition equipment for piston engines.

So outstanding was the performance of this new and better connector that its acceptance and use have now become world-wide. Today the Scintilla Division is a major contributor to the electrical connector industry.

This pioneering has never stopped. Bendix was first in the field with cadmium plated connectors, which were later made a requirement of military specifications. Our latest contribution is the best engineered closed entry socket contact available anywhere—one which cannot be mechanically overstressed.

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Bendix

The F9F-9 Tiger, designed by Grumman Aircraft Engineering Corporation, made its first flight early in August. This was less than 15 months after Grumman received a Letter of Intent from the Navy's BuAer. The F9F-9 Tiger is powered by a J-65 Sapphire turbojet engine with afterburner, produced by Curtiss-Wright Corporation's Wright Aeronautical Division. The Tiger is reportedly one of the few combat airplanes capable of supersonic speeds in level flight. The aircraft, "nosing" into the picture at the right, is a Cougar, Grumman's present production Navy jet fighter.

at the top, will be built into the left side of the fuselage aft of the wing. The design range, with 1,730 gal. of fuel, is 2,000 miles. The service ceiling will be 26,700 ft. The Freighter will be powered by two R-2800 Pratt & Whitney engines turning three-bladed variable-pitch Hamilton Standard propellers.

• **Cornell Aeronautical Laboratory, Inc.** ...An announcement was made recently concerning a major wind-tunnel modernization program that will double the power of the large variable density tunnel at Cornell Laboratory and will permit further exploration of the transonic speed range. The project, sponsored by the USAF and administered by the U.S. Army Corps of Engineers, will cost $1,600,000. It calls for an increase from 15,000 to 30,000 hp. and a change to an 8- by 10-ft. transonic throat section of Cornell's original design. The section will be used for study of airplane and missile models up to speeds of $1^1/_4$ that of sound. The Air Force will provide a set of compressors, electrical drive equipment, and additional cooling towers. In addition to the $1,600,000 Government expenditure, the Laboratory will spend $200,000 of its own funds on the transonic throat modifications. The Cornell transonic perforated throat will permit testing of models with wing spans up to 5 ft.... Ira G. Ross, MIAS, formerly Head of the Laboratory's Wind Tunnel Department, has been named Director of Cornell Aeronautical Laboratory. Appointed to the post of Associate Director was William M. Duke, AFIAS, formerly Assistant Director—Technical.

• **Douglas Aircraft Company, Inc....** The DC-7C, tagged the "Seven Seas," has gone into production at Douglas and is expected to go into air-line operation by the summer of 1956. The DC-7C, it was said, has an operating range of more than 5,000 miles and will be able to cruise at 350 m.p.h. with a full pay load. It has a wing span of 127 ft., 6 in.—10 ft. more than earlier DC-7 models. The increased span, added to the center wing section, increases the fuel capacity to 7,860 gal.; the DC-7B has a 6,400-gal. fuel capacity. The greater span also places the engines and propellers 5 ft. further away from the fuselage. The cabin of the DC-7C has been extended 40 in. forward of the wing to make a total fuselage length of 112 ft., 3 in. The vertical stabilizer measures 30 ft., 7 in. from the ground. The DC-7C is designed to take off with 140,000 lbs. and to land with 107,000 lbs. In the de luxe version, the Seven Seas will be able to carry up to 62 passengers plus baggage, cargo, and mail for a distance of 5,000 miles with adequate reserve fuel. This new intercontinental air transport will be powered by an advanced model of the Wright turbocompound engine.

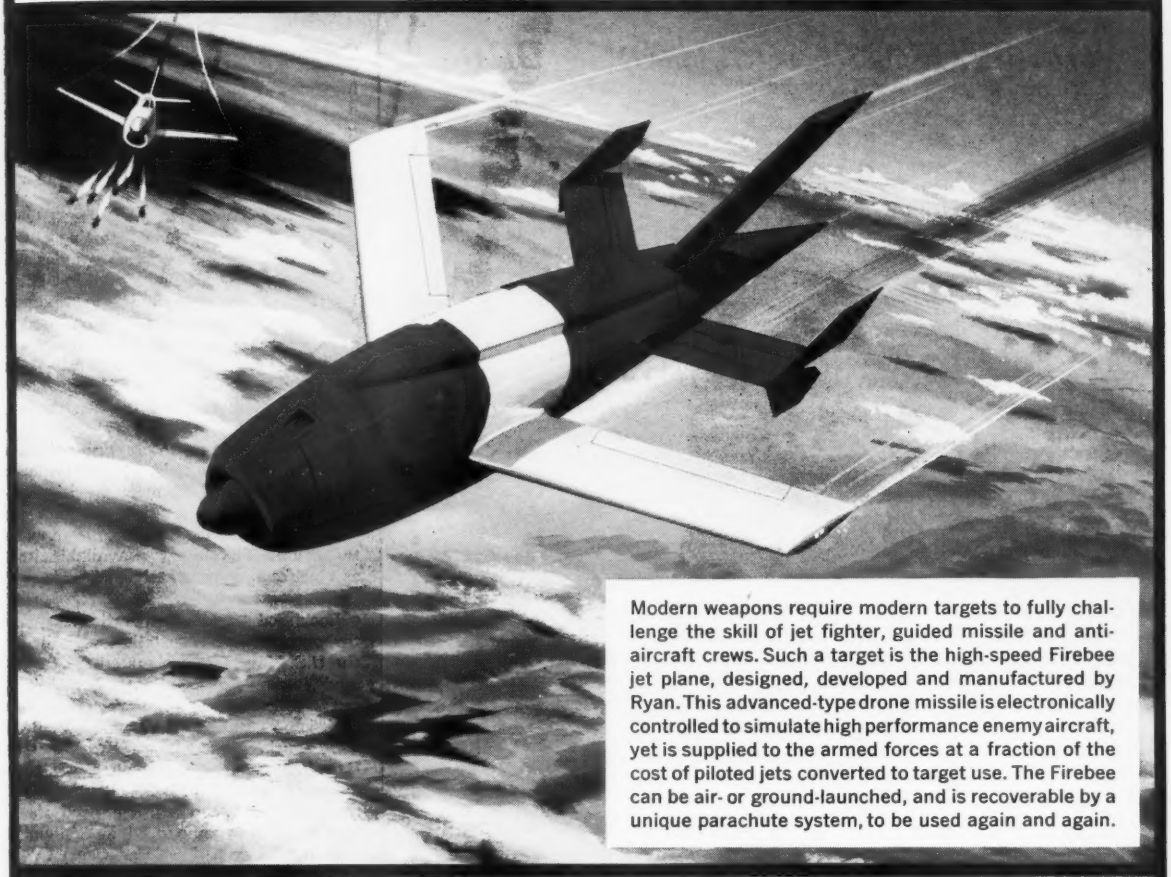
• **Fletcher Aviation Corporation...** The Fletcher "Utility," designed for agricultural work, has gone into volume production at the corporation's Rosemead, Calif., plant. The Utility made its first flight on July 14. This agricultural airplane is designed to lift a 1,250-lb. load from an 870-ft. unimproved farmer's flight strip. The wing span is 42 ft.; the overall length, 31 ft., 10 in.; and the height, 9 ft., 4 in. The operational gross weight is 3,478 lbs. Powered by a 225-hp. Continental engine, the Utility has a maximum speed of 124 m.p.h. and a cruising speed of 108 m.p.h. Its range is 370 miles. The airplane has a specially treated metal hopper capable of holding 1 cu.yd. (27 cu.ft.) of fertilizer or whatever cargo is desired; space is provided back of the hopper to carry two farm hands to assist in loading the aircraft.

• **General Electric Company...** A new lightweight constant-speed alternator drive for aircraft has been developed by the company's Aeronautic and Ordnance Systems Division. The new drive is composed of ball-piston hydraulic units and, when combined with a 400-cycle a.c. generator, reportedly makes available all the benefits of a.c. electrical power without the use of inverters. Drive efficiency averages approximately 80 per cent, with the weight of the unit being in the order of 1 lb. per hp. in 85-hp. drives and about 2 lbs. per hp. in small drives. Production of these new drives, which will operate either on a separate oil supply or on the engine oil system, are currently planned in sizes from 15 hp. (9 kva.) to 85 hp. (60 kva.).... A new 3-cm. pulse magnetron, designed to operate without pressurization up to 60,000 ft., has been announced by G-E's Tube Department. Designated type GL-6527, this tube is for use primarily in air-borne radar gunsights and is interchangeable electrically and mechanically with the type 2J42 magnetron. The GL-6527 tube weighs 3 lbs. It is a forced-air-cooled fixed-frequency pulsed-type oscillator with a 9-kw. peak-power output. It operates at frequencies between 9,345 and 9,405 mc. . . . The establishment of a new G-E electron tube development laboratory on Stanford University land has been announced by General Electric and Stanford. The laboratory is housed in a newly completed 10,000-sq.ft. structure built by Stanford and leased along with the adjacent property to General Electric. The structure is located near the educational campus in the industrial and technical center being developed by Stanford within the Palo Alto, Calif., city limits. It was stated that there are no formal ties between Stanford and G-E other than the laboratory-building lease and an agreement covering scholastic opportunities for G-E laboratory employees.

• **The Goodyear Tire & Rubber Company...** A "radically new and improved winged tow target for gunnery practice at high altitudes" has been designed and constructed by Goodyear Aircraft Corporation in cooperation with ARDC's Wright Air Development Center. It is an all-metal 1,400-lb. target with a 25-ft. wing span and gives an appearance of a modern jet fighter. It may be towed at speeds in excess of 500 m.p.h. and as far as 2 miles behind its medium jet-bomber tow plane. It is made to perform evasive maneuvers either automatically or by direct control from the tow plane. A method has been devised which permits the target to be towed to one side of the tow plane instead of directly behind it. A tow-cable release device has been installed which operates when the target touches the ground on its skid-type runners. This tow target is undergoing extensive tests by GAC and USAF engineers at an Air Force test station.... It was recently announced that Goodyear is prepared to make wheels and tubeless tires in any size for all types of airplanes. The company is not currently in production on commercial sizes of tubeless tires and wheels, but it expects to meet this demand when it comes. Advantages of the tubeless airplane tires over the conventional tires and tubes are given as follows: (1) an estimated 40 per cent saving in weight; (2) slightly cooler running; (3) elimination of inner-tube failure; and (4) easier installation. Goodyear is currently designing all of its tubeless airplane wheels so that they can be used with both the tubeless tire and the conventional tire and tube.

• **Lear Incorporated...** Three test stands have been developed by Lear which permit

FIREBEE...TARGET FOR TODAY



Modern weapons require modern targets to fully challenge the skill of jet fighter, guided missile and anti-aircraft crews. Such a target is the high-speed Firebee jet plane, designed, developed and manufactured by Ryan. This advanced-type drone missile is electronically controlled to simulate high performance enemy aircraft, yet is supplied to the armed forces at a fraction of the cost of piloted jets converted to target use. The Firebee can be air- or ground-launched, and is recoverable by a unique parachute system, to be used again and again.

Another Example of How

RYAN BUILDS BETTER

Already a seven league stride ahead of other target planes and towed targets, the Firebee drone missile has a large growth factor for future development. Its development demanded special ingenuity and the most advanced scientific knowledge. This achievement is just one of a long list of solid contributions in the company's 32 years of consistent growth in building the planes and aeronautical products which have helped develop America's air power.

Specialized, yet versatile, Ryan is uniquely equipped for today's difficult research, engineering and production tasks. It excels in the ability to create and produce complex, high quality products at low cost—and deliver them on time.

Engineers looking for a challenging future will find outstanding opportunities at Ryan.

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Optically flat cathode-ray tubes are conveniently rack mounted for single-sweep photography and adjustment.

Now ... the first significant basic advance in multi-channel recording in over a decade, the new Miller CR-1 Cathode-Ray Recording Oscillograph breaks through the "5-kc Barrier" and makes it possible to record up to 16 separate channels at frequencies as high as 50,000 cycles per second. High chart speeds and a patented Miller Optical System provide excellent resolution and clearly readable, permanent records.

A completely self-contained instrument system in a single cabinet, the CR-1 is a convenient, ideal solution to many of today's—*and tomorrow's*—research and development problems. Key features include:

- 16 time-synchronized channels on 8" photographic record.
- Continuous recording of phenomena as high as 50,000 cps; single-sweep photography as high as 250,000 cps.
- Record speeds from 3" to 400" per second through push-button controls; record lengths to 300 feet.
- High-precision system for 1/10, 1/100 and 1/1000-sec. timing lines.
- Automatic record-identification and reference trace recording.
- Unusual ease of operation — individual controls for all channels.
- Integrated, single-cabinet construction—portable and accessible.

Complete information on the CR-1's operation, characteristics and construction will be sent promptly. Write to our Pasadena office:

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WM MILLER INSTRUMENTS, INC.

CUSTOM INSTRUMENT DESIGNERS AND MANUFACTURERS

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testing of general-application electromechanical equipment manufactured by Lear or any other company. The three units, housed in modern slope-fronted steel cabinets that measure 3 ft. by 4 ft. by 35 in., are designated LT-1043, LT-1044, and LT-1045. Model LT-1043, the Linear Actuator and Screwjack Test Stand, has a cam-setting device and a removable drive dynamometer; the loading device, a horizontally mounted double-action hydraulic cylinder, can accommodate large units; suitable coupling adapters are supplied for each unit to be tested. Model LT-1044, the Rotary Actuator and Power Unit Test Stand, provides an electronic timer and revolution counter; dynamometers covering desired testing ranges are supplied, with a cam-setting index as a part of each dynamometer. Model LT-1045, the Motor Test Stand, incorporates a photoelectric tachometer that is used in conjunction with two homopolar absorption-type dynamometers covering six force ranges; standard for d.c. motor testing, it can be adapted for a.c. motors; coupling adapters for all types of fractional horsepower motors are supplied. These three test stands, which have been designed primarily to meet precision aircraft-accessory test requirements, are also suitable for military, air-line, or manufacturing use. The stands are available either as a package or separately.

• **Lockheed Aircraft Corporation**...A new turboprop Super Constellation, built for the U.S. Navy and designated the R7V-2, made its first flight on September 1. This military personnel-cargo-evacuation aircraft is powered by four Pratt & Whitney T-34 turboprop engines, which turn Hamilton Standard propellers 15 ft. in diameter with 2-ft. wide blades. The transport has a top cruising speed of 440 m.p.h. It was announced in September that the Navy had ordered two R7V-2's and that the Air Force had ordered two similar ships designated YC-121F's. The newest Super Constellation has a maximum take-off weight of 150,000 lbs. and a service ceiling of 35,800 ft. The fuel supply, including two 600-gal. wing-tip tanks, is 8,750 gal. The Navy version carries 106 passengers in its overland configuration and 97 when used for overwater flights. It will be able to stow 36,000 lbs. of cargo in more than 5,400 cu.ft. of storage space. As an evacuation aircraft, it will be able to carry as many as 73 litter patients plus four attendants. The normal cruising altitude of this pressurized aircraft is 25,000 ft....A new high-pay-load line of Super Constellation air transports, designated Model 1049G, is to be manufactured by Lockheed. The 1049G incorporates 107 new design features, including 600-gal. wing-tip tanks that will be optional equipment This aircraft will accommodate up to 24,300 lbs. of pay load across the United States or 23,500 lbs. across the Atlantic (tourist seating). Model G Super Constellation will be built to take off with a maximum gross weight of 137,500 lbs. and to land with 113,000 lbs. Its top speed will exceed 370 m.p.h., while its maximum cruising speed will be around 335 m.p.h. It will be powered by four 3,250-hp. Wright DA3 turbocompound engines....A new department, known as

when is an airplane great?

...When its performance characteristics solve critical operational needs.
...When its versatility permits a wide range of functions.
...When a strong growth potential is inherent in its basic design.
...When it is a "pilot's airplane", essentially simple and easy to fly.
...And finally when it's out of engineering and in the air—when it's being delivered and in operation.

The Martin B-57—brilliant new member of the Air Force's family—is in truth a great airplane. Low wing loading gives it take off and high altitude performance characteristics exceptional in the reconnaissance bomber class, and the Martin rotary bomb door makes it capable of both high and low-level bombing runs at fighter speed.

Basic configuration changes now make possible adaptions of the USAF B-57 to cover a wide variety of critical missions.

But for the final word on this remarkably versatile airplane—ask the man who has flown one.

You will hear more about Martin!

MARTIN
BALTIMORE · MARYLAND

the Physics Research Department, has been formed at Lockheed. It is composed of the following three groups: optics, acoustics, and servomechanisms. Dr. Bernhard A. Rose, MIAS, has been named to manage this newly formed department. . . .The sum of $10,000,000 has been appropriated to finance the establishment of a new scientific laboratory for advanced research by the Missile Systems Division. It was said that research in the nuclear field will receive heavy emphasis in Lockheed's new laboratories. Products of the corporation's scientific research will be determined only after exploration of many "promising recent developments which must now remain secret," it was further stated. Heading the new research laboratory will be Dr. E. H. Krause, a nuclear physicist who recently resigned as Associate Director of Research at the Naval Research Laboratory in Washington, D.C.

• **Lockheed Aircraft Corporation and Seaboard & Western Airlines, Inc....**On September 7, Lockheed began to deliver to Seaboard & Western a fleet of four of the "fastest and largest commercial cargo airplanes ever built." This is the all-cargo Super Constellation that can lift 18 tons of freight across the Atlantic in 5,500 cu.ft. of cargo space. This aircraft, powered by four Wright turbocompound engines, cruises at 335 m.p.h. If the need should ever arise, this all-cargo aircraft can be converted for military use in less than 1 hour by installing seats and a galley to accommodate 109 passengers and a crew of three. With evacuation transport fittings, it could carry 73 hospital litters.

• **Marquardt Aircraft Company...**Robert L. Earle joined Marquardt on September 1 as Vice-President—Administration and Assistant to the President. Mr. Earle was with Curtiss-Wright Corporation for 21 years, having left there in 1950 to form his own electronics company. This electronics concern grew into three affiliated operations that Mr. Earle recently sold.

• **North American Aviation, Inc....**The company's modified two-place transonic jet trainer, the TF-86F, powered by a General Electric J-47-GE-27 turbojet engine, successfully completed its first test flight in mid-August. Further flight evaluation by North American's Engineering Flight Test Section was scheduled for this aircraft. Designed for advanced pilot training in high-speed flight, gunnery, and dive bombing, the trainer is rated in the 650-m.p.h. class, has a maximum service ceiling of 45,000 ft., and has a combat radius of more than 600 statute miles. The cockpit of the TF-86F has a tandem seating arrangement, dual controls, and duplicate instrument panels.

• **Pan American World Airways, Inc....** The Frye Airline Performance Trophy for 1953 has been awarded to Pan American for pioneering in the use of the upper "jet stream" in regularly scheduled commercial flight. Specifically, the award covers Pan American's regularly scheduled nonstop flights from Tokyo to Honolulu, a distance of 3,846 miles. The distance is flown at an average block-to-block speed of 334.44 m.p.h. in 11½ hours. The Frye Trophy was established by Jack Frye in 1952.

• **Piasecki Helicopter Corporation...**The U.S. Army took delivery on its first H-21C Work Horse on last August 20.

• **Radioplane Company...**H. E. Riggins has been elected Vice-President of Contract Administration. Mr. Riggins joined Radioplane in 1951 and has supervised contract administration, materiel, purchasing, and the inspection department.

• **Solar Aircraft Company...**A new ground power unit designed and built by Solar for starting jet aircraft has been announced. This ground power unit, driven by a Solar "Mars" gas-turbine engine, is said by the company to be lightweight and compact, to start under a wide variety of climatic conditions from −65° to +130°F., and to operate on various fuels. . . .John M. Dolan recently joined Solar as Vice-President—Sales. Mr. Dolan was formerly with The Hydraulic Press Manufacturing Company. . . .Leon T. Noel has been elected Vice-President—Finance and a member of the company's Board of Directors. Mr. Noel was formerly Comptroller and Vice-President. Clifford W. Snider, formerly Assistant Comptroller, was made Comptroller.

• **Sperry Gyroscope Company, Division of The Sperry Corporation...**The Air Research and Development Command has announced the development of a miniature air-borne radar to meet the space and weight limits, as well as the growing need for such radar aids, in today's faster aircraft. Its development was jointly sponsored by ARDC and Sperry over many years. This new device, manufactured by Sperry, is said by ARDC to be the smallest and lightest radar system for its high power and wide range of aircraft uses so far publicly announced. A single 5-in. radar screen combines many radar functions of search and surveillance, accurate navigation over uncharted air lanes, detection of distant storms and best weather routes, and anticollision warning of mountain tops and tall structures or other nearby aircraft while flying at any altitude up to 50,000 ft. ARDC stated that it has already tested and proved the performance ability of these functions. This 150-lb. radar system includes an oddly shaped "turtle shell" antenna that is only 18 in. in size and which is gyro stabilized for positive steadiness against a plane's pitch and roll. The system also incorporates radar beacon interrogation and reception. This combination has been officially designated as radar set APN-59. A wide choice of range scales for the viewing screen can be selected by the operator for close-up enlargements variable from 3 to 30 miles or for fixed ranges of wider areas at 50, 100, or 240 miles. Areas shown may be oriented to current heading of the aircraft or optionally to true North or any desired compass bearing for exact measurement of drift. One or more radar indicators may be operated with the system. For large planes, an optional 30-in. antenna is also being produced. The new radar set operates in the X-Band or 10,000-mc. band of the spectrum.

• **Summers Gyroscope Company...**The physical assets of Sumac, Inc., have been acquired by Summers. Sumac, Inc., has been dissolved.

• **Thompson Products, Inc....**Two Thompson executives have been elected to fill newly created posts of company Vice-President. One of these is Ed P. Riley, who was named Vice-President in charge of three of Thompson's operating divisions—i.e., Accessories, Turbine Drive, and Commercial Pump divisions. The other is Charles W. Ohly, who was named Vice-President and General Manager of Thompson's Michigan operations, embracing plants and other facilities in Detroit, Fruitport, and Portland.

• **United Air Lines, Inc....**The company's entire fleet of Mainliners is to be equipped with "tone decoders," manufactured by Motorola, Inc. These tone decoders are electronic devices that ring a bell in the Mainliner cockpit whenever ground radio operators wish to contact a flight. The cockpit bell is actuated by radio tone codes that differ for each plane, with each decoder responding only to one set of tones. Reception of the correct tones closes a relay that in turn rings a bell, alerting the pilot to tune in for a message. Thus, the pilot is relieved of continuous radio listening. These electronic devices are part of a system known as "Selcal," so named because it permits radio communications with aircraft by selective call rather than by general broadcast. . . .The expenditure of approximately $21,000,000 for new aircraft and up to $4,000,000 for the installation of air-borne radar on United's fleet has been authorized by the air-line's Board of Directors. It was announced that the new aircraft will include ten Douglas DC-6B's, two DC-7's, and five all-cargo DC-6A's. These 17 aircraft will augment United's present fleet of 179 aircraft. . . .Paul A. Bissinger and Robert E. Johnson have been elected to United's Board of Directors. Mr. Bissinger is a San Francisco business and civic leader; Mr. Johnson is Vice-President and Assistant to the President of United.

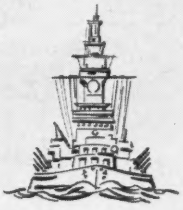
• **Vickers, Inc....**A special series of double-acting relief valves for aircraft oil hydraulic systems, designated series AA-31350, is now available. Consisting of a Vickers conventional aircraft relief valve and four poppet-type check valves combined in a single housing, the new double-acting units require only four pressure connections for installation. The combination valve is provided with tapped pressure connections or can be made to accept "O"-ring sealed flange-type mountings. The valves are adjustable for relief conditions within the pressure range (cracking pressure) of 900 to 4,100 lbs. per sq.in. A typical installation for these series AA-31350 valves, the company states, is the use with the reversing motor in air-borne winch installations. . . .The Fourth Transport Aircraft Hydraulic Conference, sponsored by Vickers, was held on November 3 and 4 in Detroit. The program consisted basically of open forum sessions covering transport aircraft hydraulic systems, with major emphasis on accessories, tubing, fittings, and hydraulic fluids.

• **Western Gear Works...**Three new accessory drive units for aircraft application, each employing a different type of lubrication, have been announced. One of these three new drive units is self-con-

GOOD MEN and GOOD IDEAS } CAST LONG SHADOWS

AC

RESEARCH · DEVELOPMENT · PRODUCTION



AC DEFENSE PRODUCTS

AC SPARK PLUG DIVISION
GENERAL MOTORS CORPORATION
FLINT, MICHIGAN

The effect of good ideas can be felt the length and breadth of the land—particularly ideas in research, development and production for defense.

Such ideas are rare. But, AC is proud of the many it has already contributed, and the part they have already played in America's defense through the T-38 Skysweeper, the A-4 Gun-Bomb-Rocket Sight, the Bombing Navigational Computer and others, many of which may not be mentioned here.

AC's people and AC's ideas have already cast a long shadow. But, this is only a beginning. The AC organization, with a group of more than 700 highly trained engineers, is rapidly forging to the very front of the electro-mechanical field.

If you would like a hand with an electro-mechanical problem of your own, why not give AC a call?

DEFENSE PRODUCTS **of High Quality at Low Cost** DELIVERED ON TIME

tained; another is engine lubricated; and the third is lubricated by hydraulic fluid. The units are: Model 166 1676E2, an alternator drive gear box; Model 1604E35, a hydraulic pump drive; and Model 1651E130, a hydraulic pump adapter. These three units will operate within a temperature range of −65° to +200°F.

Meet Your Section Chairman

Eugene J. Manganiello

Cleveland-Akron Section

Eugene J. Manganiello, a native of New York City, was graduated from the College of the City of New York with a B.S. degree in Engineering in 1934 and an Electrical Engineering degree in 1935. He joined the staff of the NACA Langley Aeronautical Laboratory in 1936 and, 6 years later, was transferred to the NACA Lewis Flight Propulsion Laboratory as Head of the Heat Transfer Section.

In 1945, Mr. Manganiello was appointed Chief of the Thermodynamics Branch at the Lewis Laboratory and in 1949 became Assistant Chief of Research.

Two years ago, in 1952, he was named Assistant Director of the Lewis Flight Propulsion Laboratory, the position he now holds.

He is an IAS Associate Fellow and an honorary member of Pi Tau Sigma. He resides with his wife and three children in Fairview Park.

IAS Sections

Columbus Section

P. V. Titus, *Secretary*

The officers of the Columbus Section for 1954–1955 are as follows: Chairman A. G. Winnett; Vice-Chairman, Dr. John D. Lee; Secretary, P. V. Titus; and Treasurer, W. Solomon. The Executive Board is composed of: D. T. Williams, S. A. Gordon, G. R. Gehrkens, Dr. Rudolph Edse, W. J. Meyer, and M. M. Blair. Commander A. L. Petitjean, USN, who was an Executive Board member, was transferred from the Columbus Naval Air Station and was replaced on the Board by Mr. Meyer.

Hagerstown Section

George W. Westphal
Outgoing Secretary-Treasurer

The following officers have been elected to serve during the 1954–1955 season of the Hagerstown Section: Chairman, T. H. Beck; Vice-Chairman, R. E. Eisiminger, Jr.; and Secretary-Treasurer, E. Stannard. W. C. Marlow is the Area Nominating Committee Representative. The members of the Advisory Council are: J. A. Neilson, L. Fahnestock, III, and E. R. Gelvin.

Los Angeles Section

Evert C. Hokanson
Outgoing Secretary

The officers of the Los Angeles Section for 1954–1955 are as follows: Chairman, Warren T. Dickinson; Vice-Chairman, George R. Mellinger; Secretary, Joseph W. Wechsler; and Treasurer, Evert C. Hokanson. The Area Councilor is Harold Luskin.

San Diego Section

H. C. Matteson
Corresponding Secretary

On August 19, the San Diego Section held a "Family Night." This was an innovation at San Diego, and the response was most gratifying to the meeting's Co-Chairmen, Earl Hinz and Ralph Grey. One hundred and seventy-five members, wives, children, and guests gathered in the auditorium of the IAS building for a buffet supper at 6:30 p.m. This was followed by two movies designed to appeal especially to the younger members of the gathering. The movies were entitled *How an Airplane Flies* and *Aeronautical Oddities*.

The meeting afforded the families of the newer members an opportunity to become acquainted with everyone else and provided a wholesome evening of family entertainment for all. It was conservatively estimated that at least 65 aeronautical engineers of the coming generation received their initial inspiration from this meeting.

Student Branches

Cal-Aero Technical Institute

Leo C. Ferns, Jr.
Secretary-Treasurer

The Cal-Aero Technical Institute Student Branch of the IAS held its July 14 meeting at the Tastee Delicatessen and Sandwich Shoppe in Glendale, Calif. After a most enjoyable dinner, the meeting got under way.

The newly elected Chairman, Dick Scharr, was presented to the attending members by the outgoing Chairman, Ed Lundby. Mr. Scharr then presented the new Secretary-Treasurer, Leo C. Ferns, Jr.

After the installation of the new officers, Mr. Scharr introduced the guest speaker. He was Pete Bonotaux, President of the Lake Elsinore Glider Club, who gave an interesting talk on gliders and soaring. Mr. Bonotaux illustrated his informal speech with pictures that he passed around the group.

Indiana Technical College

Harold R. Woodhouse
Outgoing Secretary

The summer term activities of the IAS Student Branch at Indiana Technical College consisted of four meetings held on June 8, June 22, July 6, and August 3.

Bernard Heyl received a commendation for his report entitled "Some Aspects of Aircraft Wing Design," which he submitted to the St. Louis Section Student Competition. Members who intend to submit a report for next year's Student Competition were urged to start accumulating data early.

It has been suggested by some of the members that the Student Branch initiate a design program. The proposed program would give the members an opportunity to apply their knowledge of aeronautics to practical problems. The type of aircraft to be designed would be limited to either the racer or trainer class of aircraft.

The new officers of the fall term are: John Wright, Chairman; Norman Baker, Vice-Chairman; Walter Blake, Treasurer; and Bernard Heyl, Secretary.

EEMCO

technical bulletin

a New MOTOR

for hydraulic pump in a guided missile

EEMCO Model D-638 was designed and produced for a leading airframe manufacturer for use in guided missiles where greatest power output per pound of weight is imperative. Specifications called for a 400 cycle A.C. motor operating on 200 volts, 20 amperes, at 2250 r.p.m. and a continuous duty cycle of 3.0 seconds at 6.5 HP and 15.0 seconds at 1.5 HP. **EEMCO's D-638,** weighing 17.5 lbs., was the answer. It also has a continuous rating at 5 HP of 2300 r.p.m., at 15.8 amperes. Complies with U. S. A. F. specification #32590 for 400 cycle A.C. motors. We invite your inquiry on adaptation of Model D-638 for other uses.

Designers and producers of motors, linear and rotary actuators.

SPECIFICATIONS ★ TYPE D-638

Weight: 17.5 pounds ★ **Maximum Capacity:** 6.5 HP

Volts: 200 A.C. ★ **Amperes:** 20 at 6.5 HP ★ **Cycles:** 400

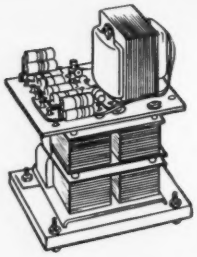
Duty cycle: 3.0 seconds at 6.5 HP
15.0 seconds at 1.5 HP

Continuous rating: 5 HP at 2300 r.p.m., 15.8 amperes, 200 volts.

Electrical Engineering and Manufacturing Corp.

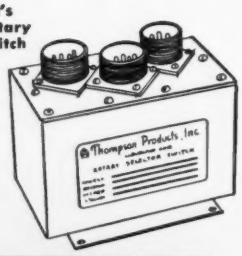
4612 West Jefferson Boulevard
Los Angeles 16, California

Thompson's Magnetic Amplifier



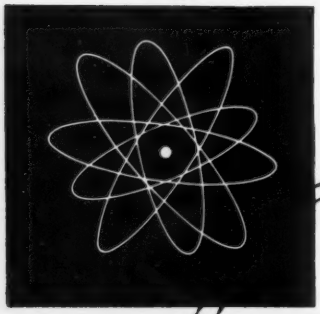
ideas...

Thompson's Airborne Rotary Selector Switch



facilities...

experience



Thompson has all three

It's no accident that more and more manufacturers are turning to Thompson to solve tough electronics problems.

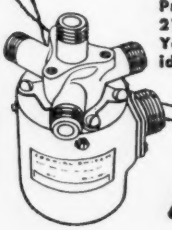
Thompson has ideas! Thompson engineers will not admit "it can't be done" for they are continually finding the answers to tough research, development and production problems.

Thompson has facilities! Complete development and testing laboratories, and modern production equipment are available to the skilled electronics engineers who make up the highly successful Thompson team!

Thompson has experience! For 52 years, Thompson has been blazing trails and making vital contributions to the automotive, aircraft and general industries of the nation. The highly valuable skills and experience of the entire Thompson organization are at your service for research, development and production of all things electronic.

FOR COMPLETE INFORMATION on how Thompson's Electronics Division can work for you, write to Thompson Products, Inc., Electronics Division, 2196 Clarkwood Road, Cleveland 3, Ohio. You will receive details of Thompson ideas ... facilities ... experience.

One of the many Thompson Coaxial Switches



Electronics Division

Thompson Products, Inc.

2196 CLARKWOOD RD., CLEVELAND 3, OHIO

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Scurton, Christopher, B.Sc., Principal Scientific Officer, National Physical Lab.

Transferred to Associate Fellow Grade

Link, Edwin A., Chairman of Bd., Link Aviation, Inc.; Pres., Link Aeronautical Corp.; Pres., Link Manufacturing Co., Ltd. (Canada).

Nesbitt, Marshall, B.Sc.—Ae.E., Asst. Exec. Engr., Douglas Aircraft Co., Inc. (Santa Monica).

Wassell, Ralph L., M.A.—M.E., Deputy Chief, Office for Aircraft Nuclear Propulsion, USAF, Hq., ARDC.

Elected to MEMBER Grade

Coleman, Robert V., B.S.Ae.E., Proj. Flight Test Engr., McDonnell Aircraft Corp.

Datner, Paul P., M.E., Sr. Engr., Aerojet-General Corp.

Davis, Richard V., B.S.E.E., Aircraft Gas Turbine Specialist, General Electric Co. (Los Angeles).

Ehreke, Gustave W., Jr., B.S.E.E., Proj. Sect. Engr., Westinghouse Electric Corp. (Baltimore).

Gayman, William H., B.A., Chief Dynamics Engr., Radioplane Co.

Goelzer, H. F., M.Sc., Research Group Engr., Ryan Aeronautical Co.

Howell, William J., Jr., Mgr., Aircraft Plastics Devel., Owens-Corning Fiberglas Corp.

Huarte-Mendicoa Larraga, Pedro, A.E., Aero. Engr. in Charge of Projects, Construcciones Aeronautics, S.A.

Ivers, John C., B.S.M.E., Application Sales Engr., General Electric Co.

Jowitt, James L., B.S.M.E., Jr. Engr., Convair Div. of General Dynamics Corp. (Pomona).

Keller, Paul F., B.S.Ae.E., Chief, Operations Dept., Southern California Cooperative Wind Tunnel, California Institute of Technology.

Levy, Ezra C., M.S.M.E., Research Engrg. Analyst, Douglas Aircraft Co., Inc. (Santa Monica).

Lobherr, Edmund P., A.B., Dir., Design Group, Aerophysics Development Corp.

May, Ralph W., Jr., B.S.Ae.E., Aero. Research Scientist, NACA (Wash., D.C.).

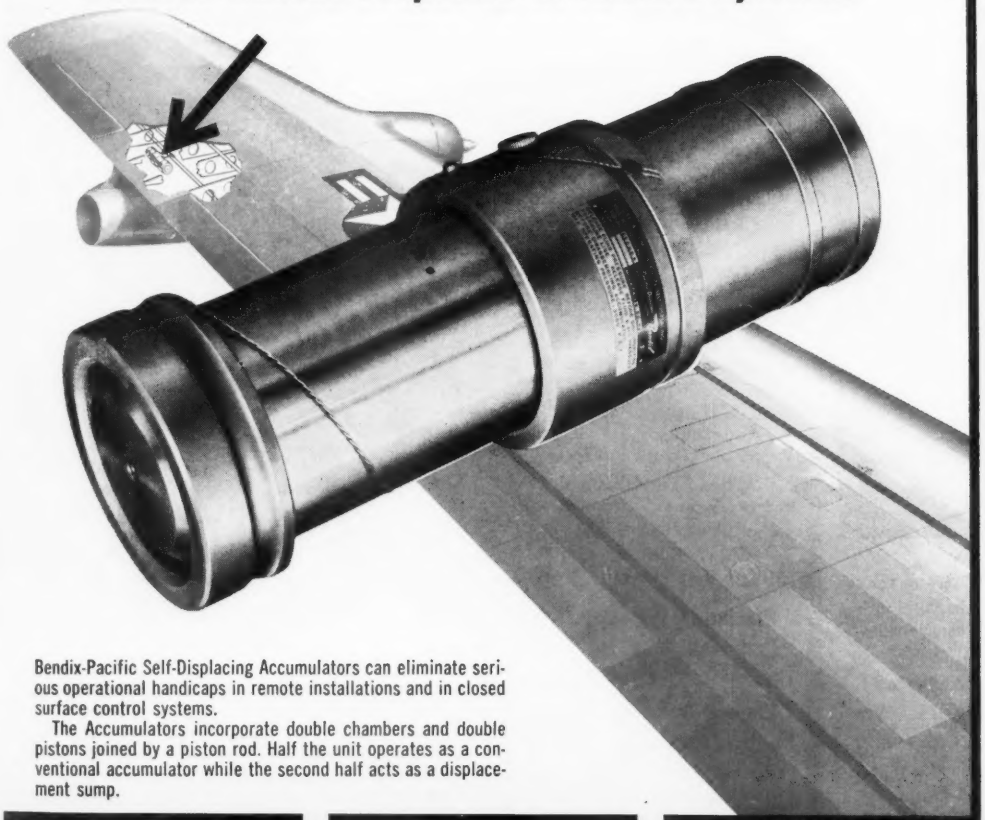
Minkin, Rose, B.S., Product Designer—Aircraft and Industrial Bearings, Shafer Bearing Corp.

Reynertson, Don L., B.Sc.M.E., Supvr. —Engr. & Customer Changes, Northrop Aircraft, Inc.

Riedinger, Louis A., M.Sc.Ae.E., Struct. Engr. "A," Douglas Aircraft Co., Inc. (El Segundo).

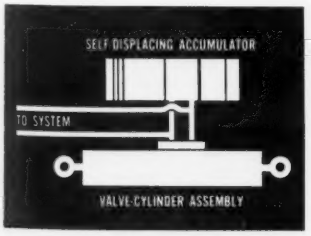
BENDIX-PACIFIC
SELF-DISPLACING HYDRAULIC ACCUMULATOR

assures instant response in remote systems

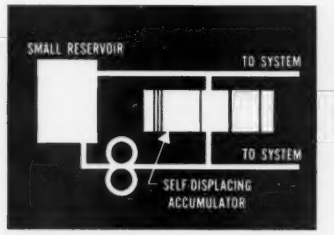


Bendix-Pacific Self-Displacing Accumulators can eliminate serious operational handicaps in remote installations and in closed surface control systems.

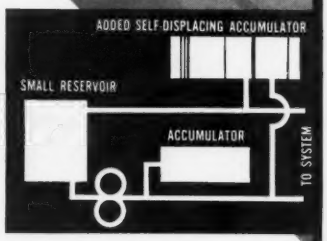
The Accumulators incorporate double chambers and double pistons joined by a piston rod. Half the unit operates as a conventional accumulator while the second half acts as a displacement sump.



For remotely located hydraulic valves which require sudden changes in rates of flow, the problems of large lines, weight, hydraulic hammer and pressure drop are virtually eliminated with the new Accumulator. It is located close to the control valve, resulting in much **faster action** and less pressure surges because the return oil travels a minimum distance.



Use of the Bendix-Pacific Self-Displacing Accumulator in an independent, completely closed hydraulic system simplifies the reservoir problem. Instead of designing a pressurized reservoir capable of accommodating the full displacement of the accumulator, it is merely necessary to provide a reservoir capable of handling expansion of the fluid, plus piston rod displacement, if any.



In systems already designed which require the addition of an accumulator, use of the Bendix-Pacific Self-Displacing Accumulator may eliminate reservoir redesign as the total system volumetric change remains the same.

RADAR

SONAR

HYDRAULICS

TELEMETERING

ELECTRO-MECHANICAL

ULTRASONICS

BENDIX PACIFIC

PACIFIC DIVISION • Bendix Aviation Corporation

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East Coast Office: 475 5th Ave., N.Y. 17

Export Division: Bendix International 205 E. 42nd St., N.Y. 17

Canadian Distributors: Aviation Electric, Ltd., Montreal 9

Giannini

DIGITAL COMMUTATORS

Codes: Binary, Binary-Grey, Binary-Decimal with non-ambiguous outputs

Immediate Delivery from stock on standard models having following characteristics:

- 1,000 counts decimal (300° to 360°)
- 1024 counts—binary, grey (300° to 360°)
- torque—0.5 oz. in ball bearings
- inertia—400 gm. cm^2
- micrometer zero adjustment
- automatic alignment—no gears

CUSTOM COMMUTATORS

Commutators can be furnished to fit specific applications by either modification of standard models or wholly new designs. Some variations now available are:

- non-linear coding
- high-count multi-turn units
- ultra low torque models
- miniature size, geared units
- direct decimal coding

G. M. GIANNINI & CO., INC.
LABORATORY APPARATUS DIVISION
PASADENA 1, CALIFORNIA
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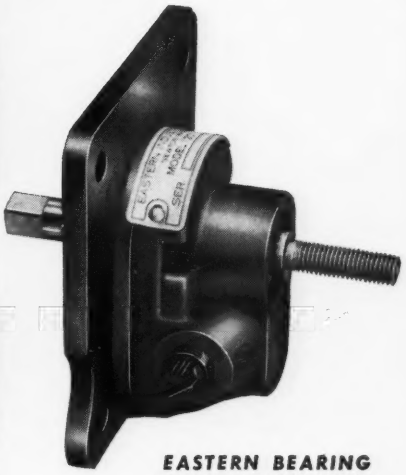

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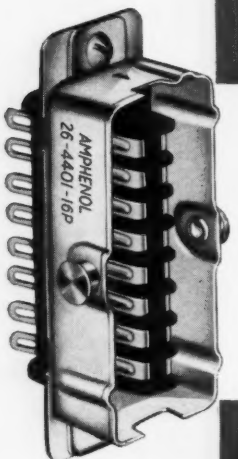

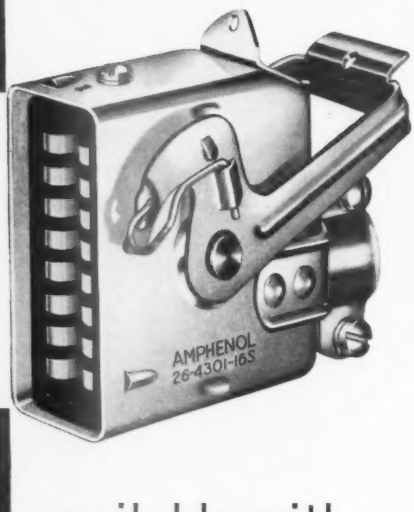

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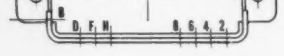

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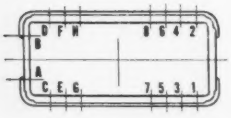

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Aerodynamics

Performance Operator. B. G. Bromberg. *ASME Fall Meeting, Milwaukee, Sept. 8–10, 1954, Paper 54-F-6.* 30 pp. Analysis of the MIT Instrumentation Lab. concept as applied in aerodynamic automatic flight control of aircraft and guided missiles.

Some Aspects of Comet Flight of Interest to the Navigator. Ian Perry. *J. Inst. Navigation*, June, 1954, p. 42. Analysis of performance in terms of design, instrumentation, cruise control and range, navigation and flight planning, and other factors.

Boundary Layer & Thermoaerodynamics

The Compressible Laminar Boundary Layer on a Yawed Infinite Wing. Appendix—Transformation of the Boundary Layer Equations of a Yawed Infinite Wing in a Compressible Fluid. L. F. Crabtree. *Aero. Quart.*, July, 1954, p. 85. 12 refs.

Examination of the Existing Data on the Heat Transfer of Turbulent Boundary Layers at Supersonic Speeds from the Point of View of Reynolds Analogy. Alvin Seiff. *U.S., NACA TN 3284*, Aug., 1954. 38 pp. 18 refs.

The Influence of Melting and Anomalous Expansion of the Thermal Convection in Laminar Boundary Layers. H. J. Merk. *Appl. Sci Res., Sect. A*, No. 5-6, 1954, p. 435.

Turbulent Boundary Layer Control by Ramps or Wedges. A. V. Stephens and G. A. Collins. *Australia, ARL Rep. A. 85*, Apr., 1954. 56 pp. Experimental development of a device to provide means of redistributing the total pressure in a boundary layer by means of wedge-shaped excrescences on the surface.

Fluid Mechanics & Aerodynamic Theory

The Application of the Electric Analogy to Two-Dimensional Problems in Aeronautics. W. B. Brower, Jr. *Rensselaer Polytech. Inst. Dept. Aero. Eng. TR AE5406*, Nov. 1, 1953. 109 pp. 112 refs. Review of the theoretical basis of the analogy; derivation of expressions relating the electrical and aerodynamic potential functions for uniform and circulatory flows, with experimental problems solved for flows about a cylinder and for those involving an airfoil and a sphere.

The Diffusion-Controlled Growth of an Aerosol in a Turbulent Medium. H. L. Frisch. *J. Meteorology*, Aug., 1954, p. 270. USAF-sponsored research at the Polytechnic Inst. of Brooklyn.

Diffusion of Heat from a Line Source in Isotropic Turbulence. Mahinder S. Uberoi and Stanley Corrsin. (*U.S., NACA TN 2710*, 1952.) *U.S., NACA Rep. 1142*, 1953. 29 pp. 31 refs. Supt. of Doc., Wash. $0.30.

On the Correlation Function in Burgers' Model of Turbulence. M. A. Hyman. *Appl. Sci. Res., Sect. A*, No. 5-6, 1954, p. 361.

The Small-Disturbance Method for Flow of a Compressible Fluid with Velocity Potential and Stream Function as Independent Variables. Carl Kaplan. *U.S., NACA TN 3229*, Aug., 1954. 18 pp.

Some Possibilities of Using Gas Mixtures Other Than Air in Aerodynamic Research. Dean R. Chapman. *U.S., NACA TN 3226*, Aug., 1954. 48 pp. 77 refs. Appraisal of relative advantages in compressible-flow studies related to the basic factor of lower speeds of sound in certain gases.

Turbulent-Heat Transfer Measurements at a Mach Number of 3.03. Maurice J. Brevoort and Bernard Rashis. *U.S., NACA TN 3303*, Sept., 1954. 21 pp.

An Approximate Solution for the Slow Flow of a Viscous Fluid. I—Flow Past a Circular Cylinder. II—Flow Past a Sphere. M. Kawaguti. (*Rep. Inst. Sci. & Tech.* [Tokyo], Nos. 3-4, 5-6, 1948, pp. 33, 66.) *Gt. Brit., MOS TIB T4327(A), T4327(B)*, June, 1954. 10, 11 pp. 17 refs. Translation.

Exact Solutions for Transonic Flow Past Cusped Aerofoils. H. C. Levey. *Australia, ARL Rep. A. 87*, Mar., 1954. 32 pp.

The Pressure Rise with Subsonic Mach Number on Fuselages and Nacelles. D. E. Hartley. *J. RAeS*, Aug., 1954, p. 567. 11 refs.

The Secondary Flow About Struts and Airfoils. Appendix—Evaluation of Definite Integrals for $\delta\Gamma$ (Biconvex Profile). W. R. Hawthorne. *J. Aero. Sci.*, Sept., 1954, p. 588. Theoretical and experimental investigation of the three-dimensional, inviscid, and incompressible flow when the approaching velocity varies in the spanwise direction to develop from the perturbation theory involved certain strut profiles.

Subsonic Compressible Flow Past Bluff Bodies. A. L. Longhorn. *Aero. Quart.*, July, 1954, p. 144. 10 refs.

An Analysis of Shock-Wave Cancellation and Reflection for Porous Walls Which Obey an Exponential Mass-Flow Pressure-Difference Relation. Joseph M. Spiegel and Phillips J. Tunnel. *U.S., NACA TN 3223*, Aug., 1954. 23 pp.

Geometrical Acoustics. I—The Theory of Weak Shock Waves. Joseph B. Keller. *J. Appl. Phys.*, Aug., 1954, p. 938. Results of research investigations at NYU Inst. for Math. and Mech.

The Shock Tube, a Versatile Tool of Aerodynamic Research. B. D. Henshall. *J. RAeS*, Aug., 1954, p. 541. Review of fundamental problems of steady and unsteady flow phenomena and a description of the apparatus used in experiments.

Internal Flow

Experimental Heat-Transfer and Friction Coefficients for Air Flowing Through Stacks of Parallel Flat Plates. Eldon W. Sams and Walter F. Weiland, Jr. *U.S., NACA RM E54F11*, Aug. 19, 1954. 33 pp.

Heat Transfer in Laminar Flow Between Parallel Plates. J. Schenk and H. L. Beckers. *Appl. Sci. Res., Sect. A*, No. 5-6, 1954, p. 405. Analysis for an arbitrary transverse temperature distribution in the liquid at the inlet.

Investigation of Turbulent Flow in Tubes of Non-Circular Cross-Section. J. Nikuradse. (*Ingen.-Arch.* [Germany], 1930, p. 306.) *Gt. Brit., MOS TIB T4288*, May, 1954. 30 pp. 14 refs. Translation.

Mechanism of the Disruption of Liquid Jets. E. G. Richardson. *Appl. Sci. Res., Sect. A*, No. 5-6, 1954, p. 374. Photographic recording of three patterns of flow from a straight nozzle, with distinctive types of break-up into drops; theoretical discussion of the sinous and atomization types.

Method and Graphs for the Evaluation of Air-Induction Systems. George B. Brajnikoff. (*U.S., NACA TN 2697*, 1952). *U.S., NACA Rep. 1141*, 1953. 21 pp. Supt. of Doc., Wash. $0.25.

A Method for Evaluating the Effects of Drag and Inlet Pressure Recovery on Propulsion - System Performance. Appendix A—Derivation of Thrust Parameter for Air-Breathing Propulsion System. Appendix B—Evaluation of Variation of Internal Thrust with Inlet Pressure Recovery. Emil J. Kremzier. *U.S., NACA TN 3261*, Aug., 1954. 21 pp.

Relative Eddy and its Effects on the Performance of a Radial Bladed Centrifugal Impeller. K. R. Reddy. *J. RAeS*, Aug., 1954, p. 547. Analytical development of experimental methods to estimate the relative eddy velocity.

Vortex Flow in Axial Turbo Machines. Jan R. Schnittger. (*Kungl. Tekniska Hogskolans Handlingar*, No. 74, 1954.) *Acta Polytechnica* (*Stockholm*), *Phys. & Appl. Math. Ser.*, No. 9 (142), 1954. 61 pp. Review of the basic nonviscous flow problem; calculation of the design by integration of the radial equilibrium equation for the interspace of the blade rows, with emphasis on the case of the entrance stages of high capacity axial flow compressors.

Wings & Airfoils

Aerodynamic Characteristics of the NACA 64-010 and 0010-1.10 40/1.051 Airfoil Sections at Mach Numbers from 0.30 to 0.85 and Reynolds Numbers from 4.0×10^6 to 8.0×10^6. Laurence K. Loftin, Jr. *U.S., NACA TN 3244*, Aug., 1954. 17 pp.

Airfoil Section Characteristics at High Angles of Attack. Laurence K. Loftin, Jr. *U.S., NACA TN 3241*, Aug., 1954. 10 pp.

The Design of Thin Finite Wings in Incompressible Flow. G. J. Hancock. *Aero. Quart.*, July, 1954, p. 119. Derivation of a formula relating the wing surface to the lift and pressure distributions over the surface on the basis of linearized theory.

Lift-Curve Slope at Subsonic and Supersonic Speeds; Graphical Presentation of Theoretical Results for Straight-Tapered Wings A. Stanbrook. *Aircraft Eng.*, Aug., 1954, p. 244. 20 refs.

A Note on the Evaluation of the Supersonic Downwash Integral. B. A. Hunn. *Aero. Quart.*, July, 1954, p. 111.

Prediction of the Characteristics of Two-Dimensional Airfoils. D. A. Spence. *J. Aero. Sci.*, Sept., 1954, p. 577. 15 refs. Formulation of the problem for the inviscid flow outside the boundary layer and wake of an airfoil on which the displacements to these regions are known, with an analytical method of solution.

Supersonic Flap Lift Effectiveness for Some General Plan Forms. Richard C. Frost. *J. Aero. Sci.*, Sept., 1954, p. 609.

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Application of the concept of reverse flow to the solution of the basic problem for the cases of subsonic and supersonic trailing edges.

Theoretical Investigation of the Effects Upon Lift of a Gap Between Wing and Body of a Slender Wing-Body Combination. Duane W. Dugan and Katsumi Hikido. *U.S. NACA TN 3224*, Aug., 1954. 41 pp. 10 refs.

Aeroelasticity

Design Methods for Selecting and Applying Vibration and Shock Isolators. I—Vibration Isolation. II—Noise Isolation. III—Shock Isolation. IV—Nonlinear Isolators. V—Isolator Materials. Charles E. Crede. *Mach. Des.*, Aug., 1954, p. 139. 19-page survey of basic principles and applications, and of selection, installation control, and other factors.

Design of an Airfoil Oscillator. Robert Maurice Williams. *Aero. Eng. Rev.*, Oct., 1954, p. 80. USAF-supported experimental development to impart sinusoidal motions in pitch and translation to airfoils of various aspect ratios.

The Effect of Tip Removal on the Natural Vibrations of Uniform Cantilevered Triangular Plates. P. N. Gustafson, W. F. Stokey, and C. F. Zorowski. *J. Aero. Sci.*, Sept., 1954, p. 621. USAF-sponsored experimental investigation at CIT for the lowest six natural frequencies and the associated nodal lines of trapezoidal plates of uniform thickness clamped on one edge.

The Evaluation of Flutter Characteristics in Design. N. P. Shevloff. (*RAeS Belfast Branch Lecture*, Feb. 23, 1954.) *Aircraft Eng.*, Aug., 1954, p. 252.

The Natural Frequency of Vibration of Curved Rectangular Plates. P. J. Palmer. *Aero. Quart.*, July, 1954, p. 101.

Vibrations of a Cylindrical Tube Containing Flowing Fluid. Frithiof I. N. Niordson. (*Kungl. Tekniska Hogskolan Handlingar*, No. 73, 1953.) *Acta Polytechnica (Stockholm), Mech. Eng. Ser.*, No. 2 (139), 1954. 27 pp. Analysis of the influence of a fluid inside or outside a cylindrical shell on its natural frequencies.

Aeronautics, General

Report of Technical Sessions, 1954 National Summer Meeting. R. G. Fuller. **I—Accessory Design Problems.** Homer Wood and John Hoch. **II—Electronics and Aircraft Electrical Systems.** John R. Moore and Roy Jackson. **III—Military Aircraft and Weapons Operations.** Edgar Schmued and Roy Jackson. **IV—Operational Flight Problems.** George Mellinger and John Hoch. **V—Human Problems of Flight.** John R. Poppen and Al Carah. **VI—Aspects of Heavy Skin Construction.** Leo Carter and Al Carah. **VII—Aerodynamics.** Clark B. Millikan and Leo Celniker. **VIII—Structures.** Jerome F. McBrearty and Rolf Buhler. **IX—Transonic Testing Techniques.** Hugh L. Dryden and Harold Luskin. **X—Confidential Design Session.** F. A. Cleveland and R. G. Fuller. *Aero. Eng. Rev.*, Oct., 1954, p. 42.

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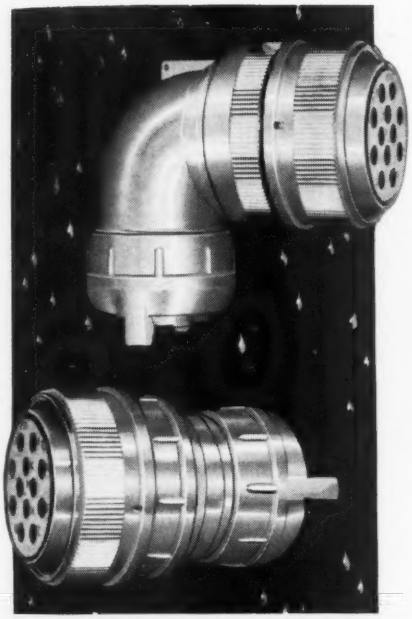

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Air Transportation

The Choice of Power Units for Civil Aeroplanes. (The 42nd Wilbur Wright Memorial Lecture, May 20, 1954.) A. E. Russell. *J. RAeS*, Aug., 1954, p. 523. Analytical evaluation of fundamental factors facing airlines, including design, performance, and economic operation.

Maintenance Procedures. Melville S. Rummel, Moderator, and others. *Skyways*, Aug., 1954, p. 18. Flight Operations Round Table discussion on the economic, safety, and other factors of maintenance in commercial operations.

Airplane Design

Aircraft of the Commonwealth—1954. *Flight*, Aug. 27, 1954, p. 277. Survey of the different designs, with structural, performance, and other technical data.

Beech T-34A Mentor. *Aero Dig.*, Aug., 1954, p. 30, cutaway drawing. Structural and operational details of the primary-trainer design.

The DC-7 Freon Cooling System. *Douglas Serv.*, May-June, 1954, p. 1. Details of component design, electrical controls, installation, and operational data.

Douglas DC-7, Latest of the World-famous Line: Its Design, Performance, and Passenger-appeal. *Flight*, July 30, 1954, p. 143, cutaway drawing. Operational and structural characteristics.

Flying Aids and Power Controls. *The Aeroplane*, July 30, 1954, p. 141. Partial contents: Radio Aids for Approach and Navigation. The Autopilot/Compass Combination. The Transport Pilot's View, R. E. Gillman. Aids for the Helicopter, Basil Arkell. Powered Flying Control Systems. Autostabilization Equipment.

Grumman F9F-8 Cougar. *Aero Dig.*, Sept., 1954, p. 33, cutaway drawing. Design, structural, and performance details of the swept-wing fighter.

Leakage Rates from Pressurised Aircraft at Altitude. H. J. Staite. *J. RAeS*, Aug., 1954, p. 574.

Percival Pembroke; High-wing Versatility; Design and Construction of a "Prince-plus." Ken T. Owen. *Flight*, Mar. 26, 1954, p. 365, cutaway drawing. Structural, operational, and other technical data. (Corrected item.)

Landing Gear

The Effective Rolling Radius of Pneumatic-Tyred Wheels. W. K. G. Floor. *Netherlands, NLL Rep. S. 428*, 1954. 31 pp. 35 refs. Study to develop design and other criteria of the phenomena occurring during spinning-up of aircraft wheels in the first phase of landing, with a method to calculate the drag load-time history for the landing gear.

Low-Speed Yawed-Rolling and Some Other Elastic Characteristics of Two 56-56-Inch-Diameter, 24-Ply-Rating Aircraft Tires. Walter B. Horne, Bertrand H. Stephenson, and Robert F. Smiley. *U.S., NACA TN 3235*, Aug., 1954. 108 pp. Investigation to obtain basic data to solve landing-gear design problems.

Papers on Shimmy and Rolling Behavior of Landing Gears Presented at Stuttgart Conference Oct. 16 and 17, 1941. (*Lilienthal-Gesellschaft für Luftfahrtforschung, Bericht 140*, 1942?) *U.S., NACA TM 1365*, Aug., 1954. 233 pp. 40 refs. Translation. Contents: Experiences in Flight Operation, E. Hoffmann. Lateral Guiding Forces on Obliquely Running Airplane Tires, R. Harling. Stiffnesses of Various Tires, H. Schrode. Force Distribution in the Contact Surface Between Tire and Runway, P. Kraft. Veering-off in Take-off and Landing, F. N. Scheubel. Veering-off (Ground Looping) of Aircraft Equipped with Tail-Wheel Landing Gears, E. Maier. Rolling Stability of Airplane Landing Gears and Resultant Requirements for Swivelling Wheels, L. Huber. On the Mechanics of the Rolling of an Airplane with a Nose-Wheel Landing Gear, T. E. Schunck. Fundamental Perceptions on Wheel Shimmy, P. Riekert. Shimmying of a Pneumatic Wheel, B. v. Schlippe and R. Dietrich. Comments on Two American Research Reports, E. Marquard. Investigation of Tail-Wheel Shimmy on the Model Me 110, M. Renz. Brief Report on the History of the Theory of Wheel Shimmy, H. Fromm. Sideslip and Guiding Characteristics of the Rolling Wheel, H. Fromm. Supplement for Clarification of Several Remarks in the Discussion, B. v. Schlippe and R. Dietrich. Oscillation Damping on the Rolling Wheel, H. Fromm.

Track Undercarriages for Aircraft. Heinz Guderian. *Interavia*, No. 8, 1954, p. 544. Appraisal of the relative merits of caterpillar track gear designs.

Aviation Medicine

Determination of Accelerative Forces Acting on Man in Flight and in the Human Centrifuge. Frederick Dixon and John L. Patterson, Jr. *U.S., Nav. Sch. Av. Med., Pensacola, Fla., Project Rep. NM 001 059.04.01*, July 1, 1953. 225 pp. 10 refs.

Human Factors in Jet-Transport Design. Frank C. Hale. *Aero. Eng. Rev.*, Oct., 1954, p. 84. Appraisal of factors of physiology, psychology, comfort control, body dimensions and dynamics, and data reduction.

Computers

The Application of the Electric Analogy to Two-Dimensional Problems in Aeronautics. W. B. Brower, Jr. *Rensselaer Polytech. Inst., Dept. Aero. Eng. TR AE5406*, Nov. 1, 1953. 109 pp. 112 refs. Review of the theoretical basis of the analogy; derivation of expressions relating the electrical and aerodynamic potential functions for uniform and circulatory flows, with experimental problems solved for flows about a cylinder and for those involving an airfoil and a sphere.

A Count-Rate Meter Having Automatic Correction for Losses Caused by Finite Resolving Time. E. W. Pulsford. *Electronic Eng.*, Aug., 1954, p. 356.

A Ferroresonant Trigger Circuit Applicable to Electronic Computing Machines. J. Garcia Santesmases. (*An. Fis. Quim., Ser. A.* [Madrid], 1952, pp. 171, 355.) *Gt. Brit., MOS TIB T4320*, June, 1954. 15 pp. Translation.

The High-Accuracy Logarithmic Receiver. T. H. Chambers and I. H. Page. *Proc. IRE*, Aug., 1954, p. 1307. Use of the "successive detection" principle to develop the design for analog computers.

Leo (Lyons Electronic Office). II—Operation and Maintenance. E. H. Lenaerts. *Electronic Eng.*, Aug., 1954, p. 335. Includes details of a general computer test program.

Multiplier for Analog Computers. C. J. Savant, Jr., and R. C. Howard. *Electronics*, Sept., 1954, p. 144. Design of a circuit using a system of logarithms applicable to the solution of nonlinear differential equations and to the improvement of the response of servo loops.

A New Binary Multiplication Method. Robert Piloty. (*ZAMM*, Dec., 1953, p. 429.) *Gt. Brit., MOS TIB T4331*, July, 1954. 4 pp. Translation. Development of the computational method with application to program-controlled calculating machines.

Programme Controlled Digital Computers (Electronic Calculating Machines). H. Rutishauser, A. Speiser, and E. Stiefel. (*ZAMP*, 1950, p. 227.) *Gt. Brit., MOS TIB T4322*, July, 1954. 19 pp. 67 refs. Translation. Review of basic principles, applicational significance, design, and operational factors.

The Selenium Rectifier in Digital Computor Circuits. A. D. Booth and A. D. Holt. *Electronic Eng.*, Aug., 1954, p. 348. Appraisal of adaptability, reliability, and operational application, with circuit details.

The Use of Digital Computers in Air Navigation. E. M. Grabbe. *J. Inst. Navigation*, June, 1954, p. 67. Developmental appraisal of reliability, relative merits, and requirements for airborne applications.

Electronics

An Accurate, High-Speed, Automatic Line-Voltage Regulator. *Gen. Radio Exp.*, July, 1954, p. 1. Design, operational characteristics, and applications of the Type 1570-A, with circuit details.

A Dual-Control Course-Line Computer CAA Type IA. William L. Seibert, Alan L. Saunders, and Logan E. Setzer. *U.S., CAA TDR 244*, July, 1954. 8 pp. Design details related to DME and VOR receiving equipment.

Flying Aids and Power Controls. *The Aeroplane*, July 30, 1954, p. 141. Partial contents: Radio Aids for Approach and Navigation. The Autopilot/Compass Combination. The Transport Pilot's View, R. E. Gillman. Aids for the Helicopter, Basil Arkell. Powered Flying Control Systems. Autostabilization Equipment.

Machine Methods Make Strip Transmission Line. K. S. Packard. *Electronics*, Sept., 1954, p. 148. Development for the fabrication of microwave components using copper-clad dielectrics at the Airborne Instruments Lab. Special Devices Sect.

False Echoes in Line-Type Radar Pulsers. Reuben Lee. *Proc. IRE*, Aug., 1954, p. 1288. Results of studies designed to formulate criteria for the elimina-

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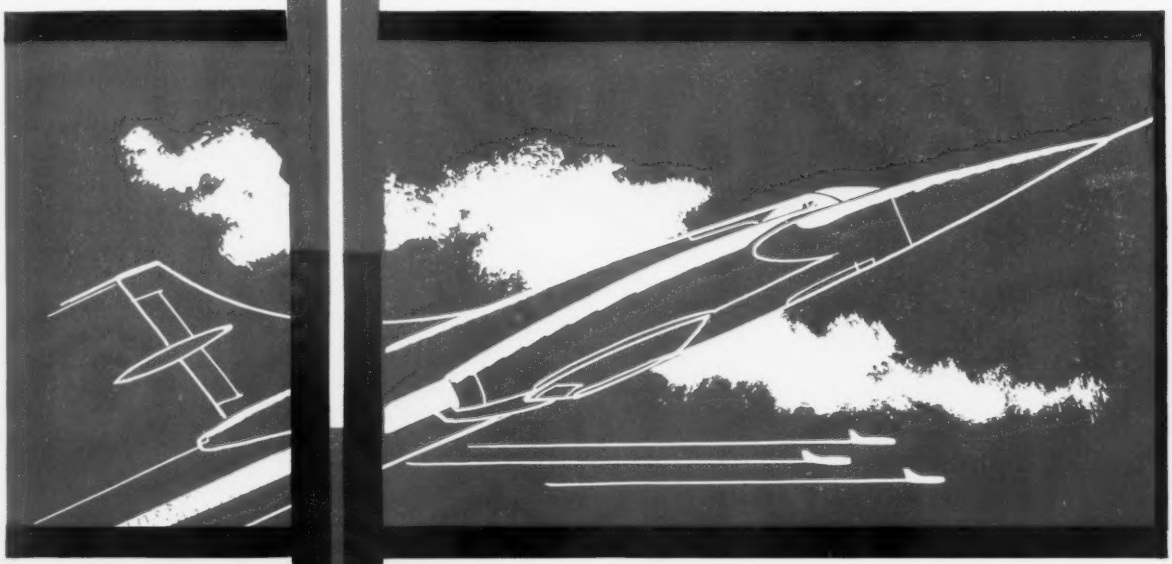

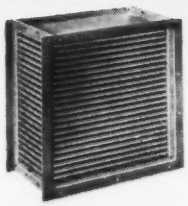

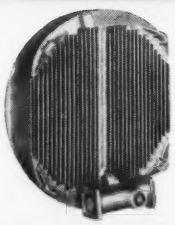

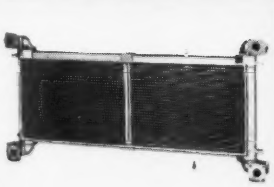

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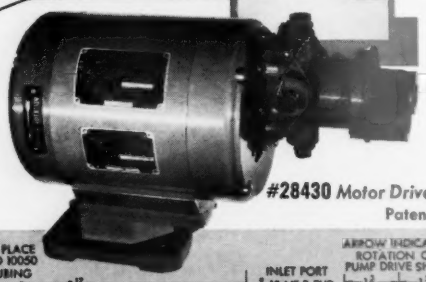

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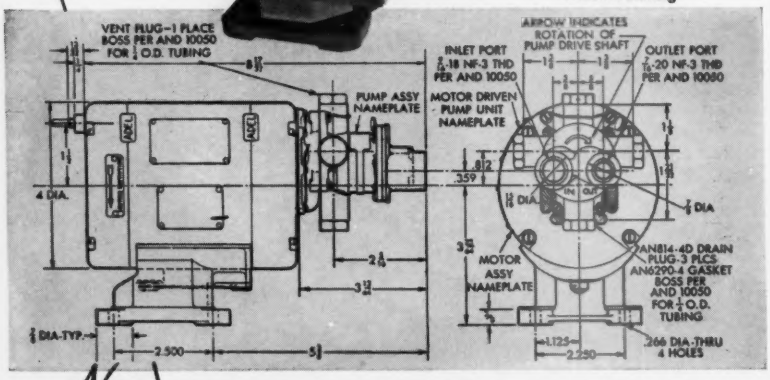

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tion of false echoes, with a derivation of appropriate equations and curves.

Moving Target Detection by Pulse Doppler Radar. R. S. Sargent. *Electronics*, Sept., 1954, p. 138. Qualitative analysis of the detection method.

Impedance Transformation by Four-Terminal Networks; Use of Graphical Methods. I. S. Fedida. *Wireless Engr.*, Aug., 1954, p. 204.

Reciprocity Relations in Active 3-Terminal Elements. Jacob Shekel. *Proc. IRE*, Aug., 1954, p. 1268.

Antennas

Designing Scale Model Aircraft for Antenna Analysis. I. Robert T. Blaine. *Tele-Tech*, Sept., 1954, p. 84. Details of the experimental and analytical technique to obtain accurate predictions of antenna performance.

Ferrite Rod Aerials; Underlying Principles and Basic Design Formulae. W. A. Everden. *Wireless World*, Sept., 1954, p. 440.

On the Design of Arrays. J. N. Hines, V. H. Rumsey, and T. E. Tice. *Proc. IRE*, Aug., 1954, p. 1262. USAF WADC-supported development at the Antenna Lab., Ohio State U. of a method to predict exactly any practical array pattern.

Circuits & Components

Component Design Trends. III—Fixed Resistors Show Stability Improvements. Frank Rockett. *Electronics*, Sept., 1954, p. 132. Developmental survey.

Designing An Electro-Thermal Relay. John J. Dietz. *Tele-Tech*, Sept., 1954, p. 65. Developmental review of characteristics and basic design principles to provide time delays adjustable from a fraction of a second to several minutes.

High-Frequency Compensation of RC Amplifiers. Frank A. Muller. *Proc. IRE*, Aug., 1954, p. 1271.

Insulation Requirements for Electronic Transformers. Reuben Lee. *Elec. Mfg.*, Sept., 1954, p. 129. Analysis of design, circuit applications, materials, fabricational, and other factors.

On the Filter Problem of the Power-Spectrum Analyzer. S. S. L. Chang. *Proc. IRE*, Aug., 1954, p. 1278.

The Transfer Function as a Tool in the Analysis of a Resistance-Capacitance Coupled Voltage Amplifier. D. L. Ming and R. W. Thorpe. *J. Appl. Phys.*, Aug., 1954, p. 934. Theoretical analysis of the frequency response, with a comparison of the result to that found by the Terman method and an appraisal of the relative merits of the two methods.

Dielectrics

Effect of Electric Discharges on the Breakdown of Solid Insulation. T. W. Dakin, H. M. Philofsky, and W. C. Divens. *Elec. Eng.*, Sept., 1954, p. 812. 13 refs.

A Method of Investigating the Secondary Emissive Properties of Insulators. C. N. W. Litting. *Brit. J. Appl. Phys.*, Aug., 1954, p. 289.

Temperature Classification of Insulating Materials. K. N. Mathes. *Elec. Mfg.*, Sept., 1954, p. 152.

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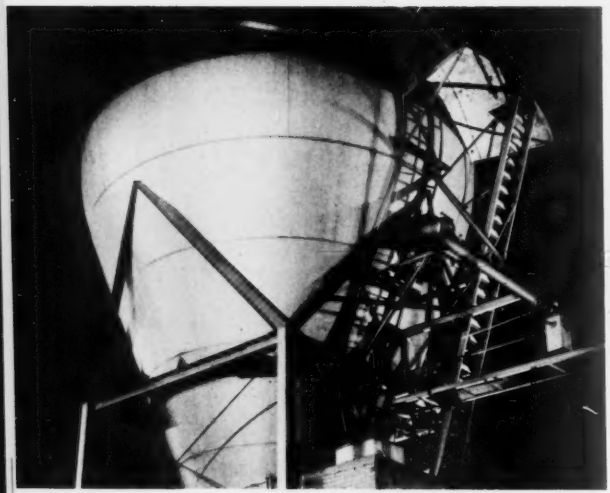

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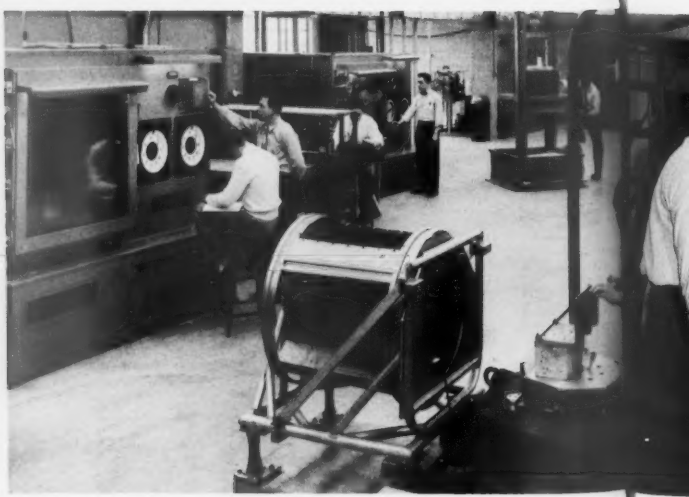

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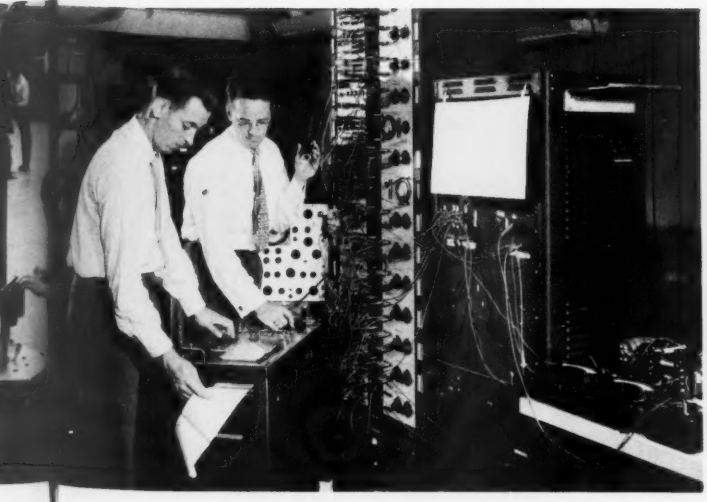

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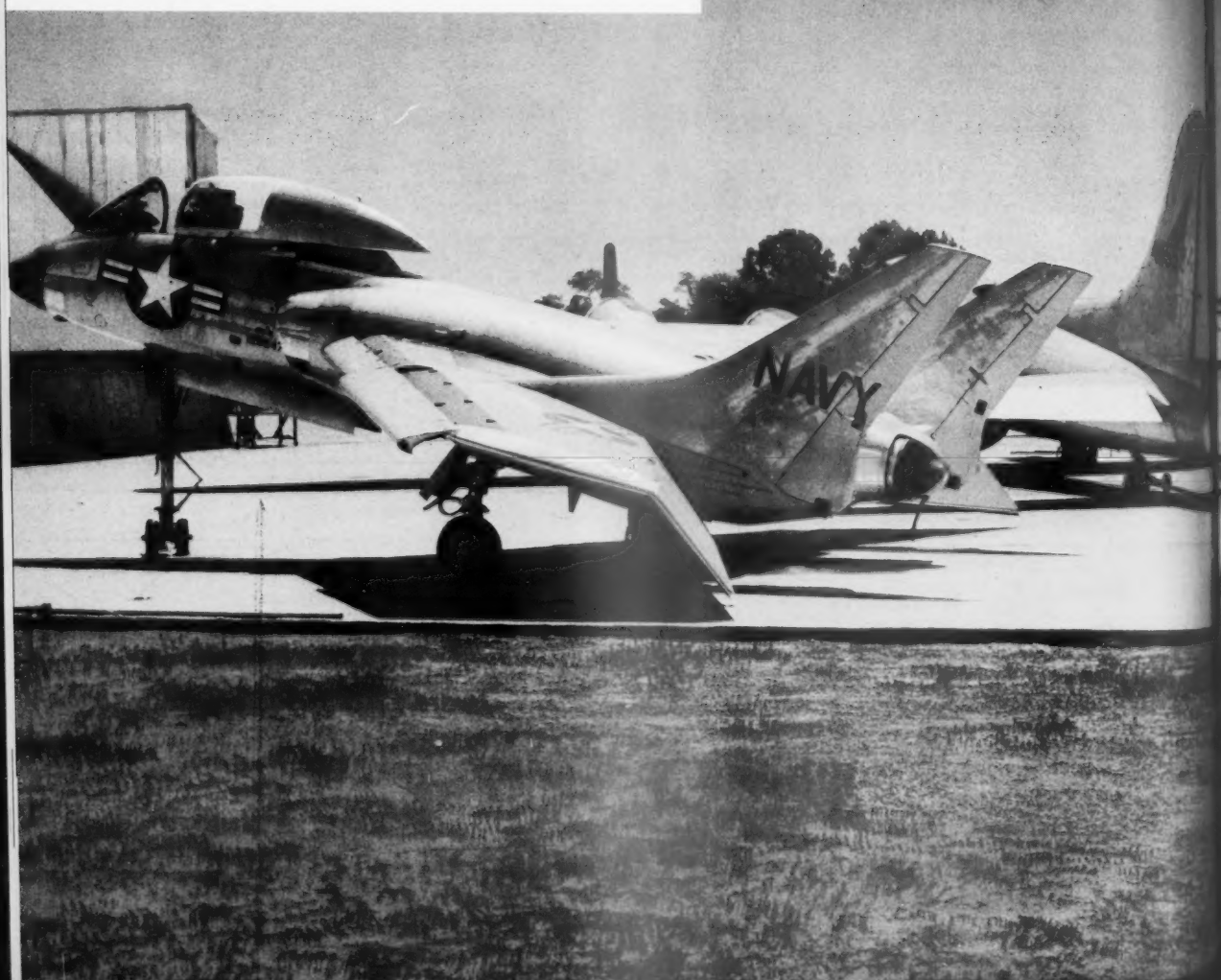

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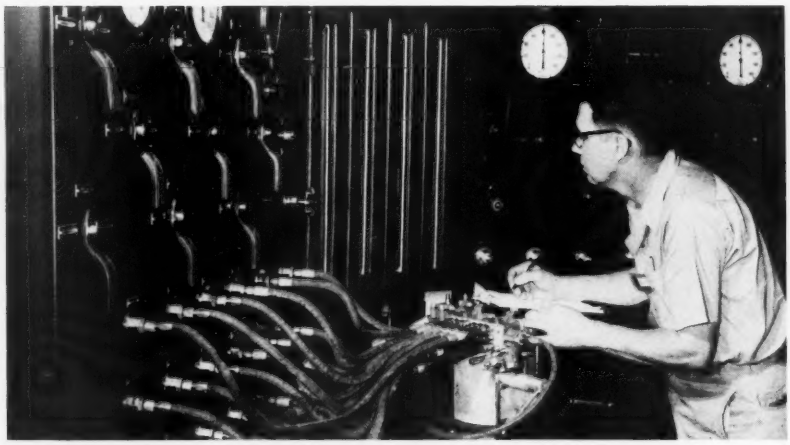
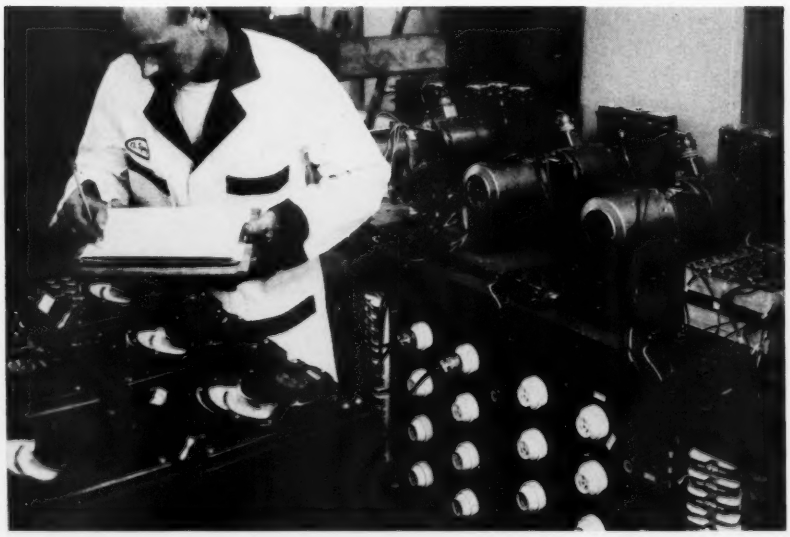


The Aviation Gas Turbine Division—like all Westinghouse Divisions—places great stress on test, evaluation and qualification of all components and products. Here, a jet engine accessory is being given a complete operational check prior to release for installation. This same attention to performance follows every engine from development through production, where completed engines are given two complete test cell runs to prove that they meet specifications.



Life testing of all electrical apparatus plays a vital part in the Aircraft Department of the Small Motor Division. Highly specialized facilities—similar to the one shown above—test generators and motors under full load to determine brush life and stamina. The results are then cross-checked with other evaluations, such as high altitude chamber tests. Complete systems and their components can be tried and proved for performance under any climatic or mechanical environment.

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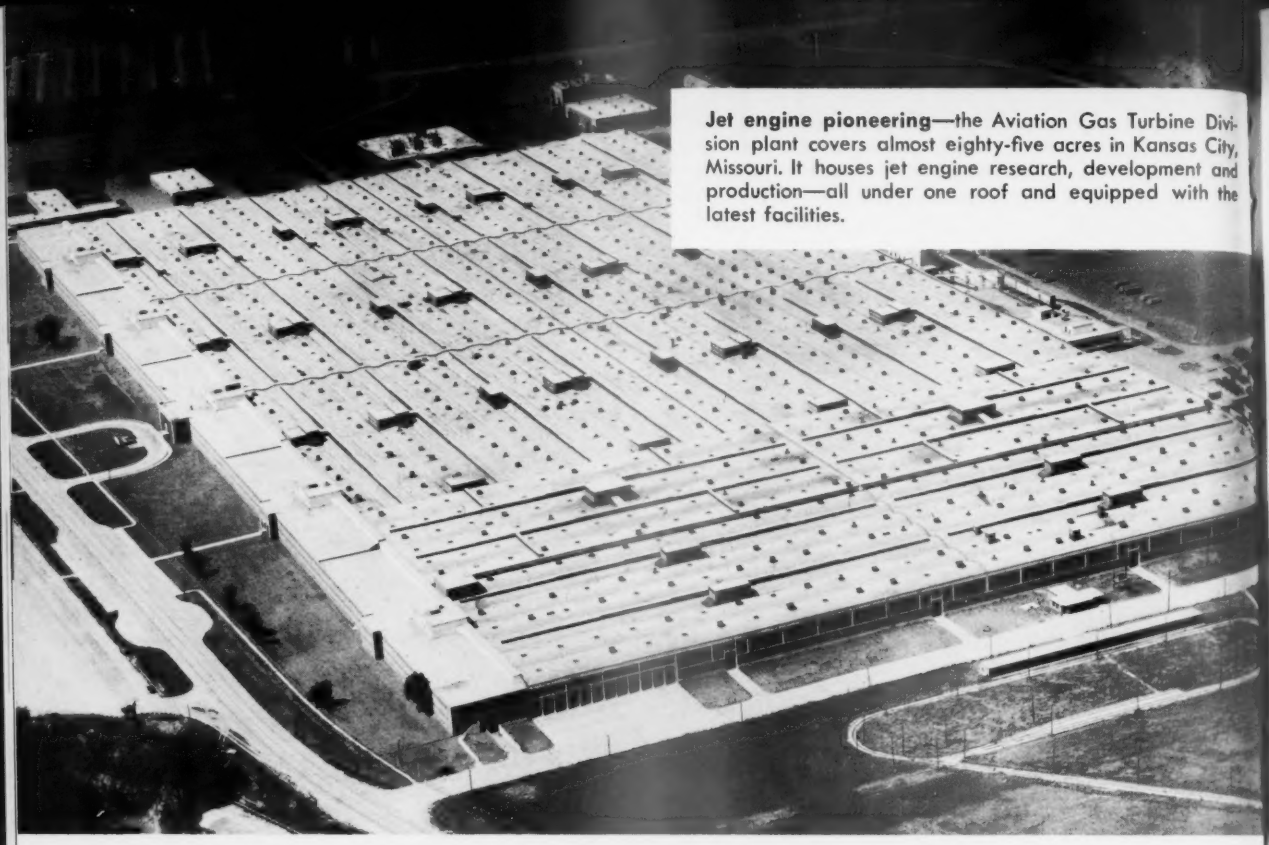

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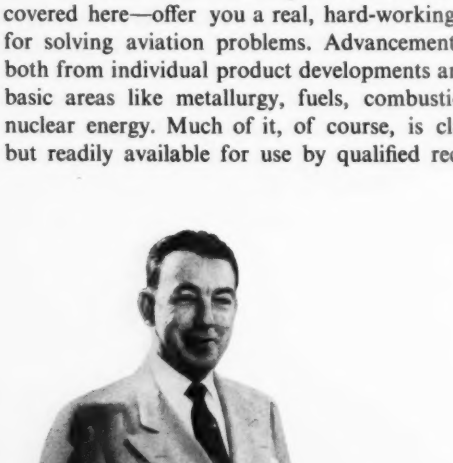

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Electronic Tubes

Induced Charges and Currents (Appreciable Space Charge Present). W. E. Benham. *Electronic Eng.*, Aug., 1954, p. 366. Analysis of electronic currents in a vacuum tube beginning with Green's Theorem to establish the potential function appropriate to the calculation of induced charge satisfying the Laplace equation.

IRE Standards on Electron Devices: Definitions of Terms Related to Phototubes, 1954. A. G. Jensen, M. W. Baldwin, Jr., G. D. O'Neill, and others. *Proc. IRE*, Aug., 1954, p. 1276.

A Magnetic Gas Discharge Tube Oscillator. J. M. Somerville. *J. Sci. Instr.*, Aug., 1954, p. 279. Analysis of the negative conductance characteristics and of the behavior and efficiency of oscillators in certain applications, including use as a counter.

A New Electron Tube: The STROPHOTRON. Hannes Alfvén and Dag Romell. *Proc. IRE*, Aug., 1954, p. 1239. Development of a new multitransit tube design for VHF and UHF communication uses.

Reliable Tubes for Automatic Production. W. R. Wheeler and T. L. Evans. *Radio-Electronic Eng.*, Sept., 1954, p. 10. Design, fabricational, and other criteria to develop uniform, rugged, and stable characteristics; applications.

Thermionic Emission and Electron Diffraction from Thin Films of Barium Oxide. Paul N. Russel and A. S. Eisenstein. *J. Appl. Phys.*, Aug., 1954, p. 954. 14 refs. ONR-supported experimental studies.

Magnetic Devices

An Electrodynamic Perturbation Theorem, with Application to Nonreciprocal Systems. Alfred G. Redfield. *J. Appl. Phys.*, Aug., 1954, p. 1021. 12 refs. Derivation of a modification of the reciprocity theorem for a generalized system applicable to electromagnetic microwave problems.

Industrial Applications of Magnetic Amplifiers. C. G. Helmick. *Instruments & Automation*, Aug., 1954, p. 1300. Appraisal of the design factors of reliability, simplicity, and efficiency and of relative merits.

Microwave Single-Sideband Modulator Using Ferrites. John Cacheris. *Proc. IRE*, Aug., 1954, p. 1242. Development of transmission and reflection devices based on the double-refraction properties of the ferromagnetic dielectrics.

The Motion of Electrons in Two Combined Magnetic Fields. Sven Gösta Nilsson. (*Kungl. Tekniska Högskolans Handlingar*, No. 72, 1953.) *Acta Polytechnica* (*Stockholm*), *Elec. Eng. Ser.*, No. 5 (137), 1954. 22 pp.

The Nondestructive Read-Out of Magnetic Cores. Athanasios Papoulis. *Proc. IRE*, Aug., 1954, p. 1283.

Saturable Transformers as Gates. Burnham Moffat. *Electronics*, Sept., 1954, p. 174. Ferrite-cored components to control the flow of information into a particular channel at high switching rates, with applications including magnetic-drum read-out systems for computers.

What Is Ferrimagnetism? L. R. Maxwell. *Elec. Eng.*, Sept., 1954, p. 804. Analysis of the theoretical concept, with an appraisal of the ferrite developmental trend.

Measurements & Testing

An Audio Frequency Phase Meter. F. P. Moss. *Electronic Eng.*, Aug., 1954, p. 361. Design for the measurement of the phase difference between two signals in the 30 cycles per sec. to 30 kc. frequency range; applications include the study of vibrational and torque-measuring problems.

An Automatic Plotter for Magnetic Hysteresis Loops. H. McG. Ross. (*IEE Measurements Sect. Paper 1637.*) *Proc. IEE, Part II*, Aug., 1954, p. 417; Discussion, p. 427. Details of a design for accurate and direct measurement and recording of hysteresis loops of magnetic materials under substantially zero-frequency conditions, with calibrations in terms of voltage and time.

A Breakdown Cell for Measuring the Dielectric Strength of Solids at 100 Megacycles. L. J. Frisco and J. J. Chapman. *Rev. Sci. Instr.*, Aug., 1954, p. 733.

Measuring Small Voltage Changes; Simplified Method Using Polystyrene Film Capacitors and Electrometer Valves. J. P. Salter. *Wireless World*, Sept., 1954, p. 451.

Measuring Time-Delay in Pulse Circuits. Melvin H. Murphy. *Tele-Tech*, Sept., 1954, p. 72. Design of pulse test gear to permit time measurements to within a few milli-microseconds.

A Method for the Measurement of Conductivity of Metals at Microwave Frequencies. S. K. Chatterjee, P. Ramdas Shenoy, and C. Rama Bai. *J. Indian Inst. Sci., Sect. B*, July, 1954, p. 107.

New Resistor Voltage Coefficient Tester. Louis A. Rosenthal and Arnold S. Louis. *Tele-Tech*, Sept., 1954, p. 62. Measurement of the harmonics generated due to the resistor's nonlinearity to predict accurately the variation of resistance with applied voltage.

Plating Quantity Indicator for L-Band Waveguides. Martin Davidson and Nicholas S. Rahal. *Tele-Tech*, Sept., 1954, p. 76. NBS-developed probe design and nondestructive test method for measuring the difference between the electrical conductivity of the base material and that of the plating.

Practical Expectations and Limitations of the Reliability Problem. Russell H. Lindsay. *Aero. Eng. Rev.*, Oct., 1954, p. 65. Appraisal of rigid testing requirements of complex electronic components in terms of "short-range" and "long-range" planning categories.

The Problem of the Exact Measurement of Alternating Currents. R. Schmidt (*VDE Fachber.* [Germany], No. 1, 1952, p. 24.) *Gt. Brit., MOS TIB T4296*, June, 1954. 12 pp. 12 refs. Translation.

Pulsed Curve Tracer for Semiconductor Testing. J. I. Pankove. *Electronics*, Sept., 1954, p. 172. 10 refs. Technique to measure the voltage-current characteristics taking into account the thermal effects.

Selenium Rectifier Testing Techniques. Edward L. Pagano. *Electronics*, Sept., 1954, p. 200.

Short-Time Frequency Measurement of Narrow-Brand Random Signals in the Presence of Wide-Brand Noise. Peter M. Schultheiss, Conrad A. Wogrin, and Felix Zweig. *J. Appl. Phys.*, Aug., 1954, p. 1025.

Noise & Interference

How to Suppress Radio Interference. John D. Cooney. *Elec. Mfg.*, Sept., 1954, p. 109. 20-page survey of component design, operational, and other problems.

On the Distributions of Signals and Noise after Rectification and Filtering. M. A. Meyer and David Middleton. *J. Appl. Phys.*, Aug., 1954, p. 1037. 16 refs. Applications include radar circuits.

A Theorem Concerning Noise in Electron Streams. J. R. Pierce. *J. Appl. Phys.*, Aug., 1954, p. 931.

Oscillators & Signal Generators

Electronic Oscillators. III—Tracking. Eng. Dept., Aerovox Corp. *Aerovox Res. Worker*, Nov., 1954, p. 1. Review of basic principles, circuit problems, and applications.

Frequency Stable LC Oscillators. J. K. Clapp. *Proc. IRE*, Aug., 1954, p. 1295. 11 refs. Formulation of a simple theory of the conditions for oscillation.

Junction Transitor Pulse Forming Circuits. J. B. Oakes. *Electronics*, Sept., 1954, p. 165. NAVORD-supported analysis of integration and differentiation circuits using *npn* junctions as applied in saw-tooth, square-wave, and pulse generators and in the triangular-wave differentiator.

The Radiation Green's Functions. J. G. Linhart. *J. Franklin Inst.*, Aug., 1954, p. 99. Applications include study of electromagnetic problems of microwave oscillators.

Van der Pol's Equation; Analytic Method of General Solution. Ziya Akcasu. *Wireless Engr.*, Aug., 1954, p. 198. Results of the solution applied to the problem of a thermionic generator, taking into account the effect of harmonics.

Wide-Band UHF Sweep Frequency Generator. Richard D. Bogner. *Tele-Tech*, Sept., 1954, p. 60. Details of design and construction, with oscilloscopic applications in the 200-2,000 mc. range.

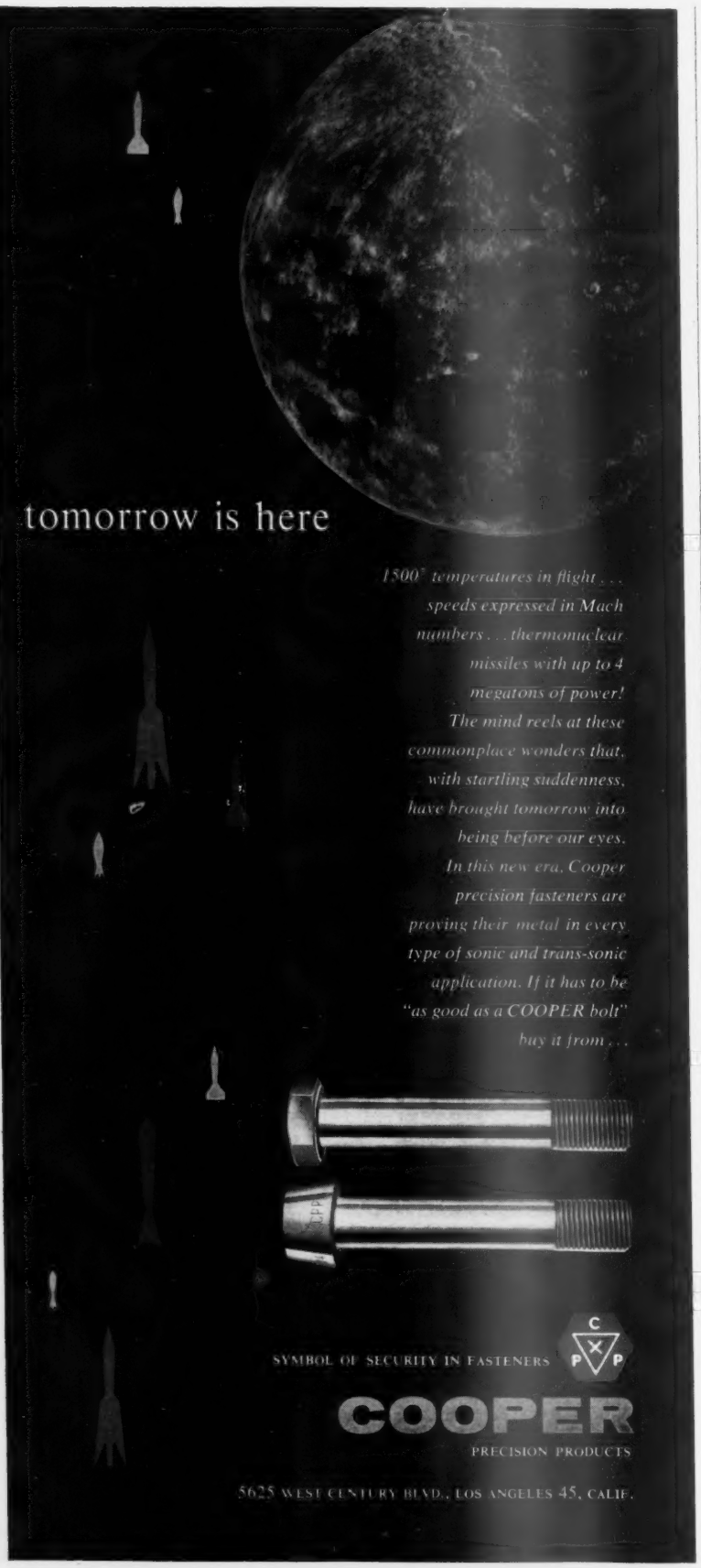
Semiconductors

Analysis of Junction Transistor Audio Oscillator Circuits. J. B. Oakes. *Proc. IRE*, Aug., 1954, p. 1235. NAVORD-supported research at Johns Hopkins U.

Developmental Germanium Power Transistors. E. G. Roka, R. E. Buck, and G. W. Reiland. *Proc. IRE*, Aug., 1954, p. 1247.

Electrical Properties of Titanium Dioxide Rectifiers. T. S. Shilliday and C. S. Peet. *Elec. Mfg.*, Sept., 1954, p. 102. USAF WADC-sponsored development at the Battelle Memorial Inst. to utilize the semiconducting film for high-temperature operational applications between minus 65° and plus 200°C.

Feedback and Stability of Junction Transistor Circuits. Appendix A—Measurement of Transistor Network Coefficients. Appendix B—Return Difference and Sensitivity for Transistors. Donald W. Gade. *Iowa Eng. Exp. Sta. Eng. Rep.*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19, Apr. 7, 1954. 56 pp. 52 refs. Analysis of equivalent, single-stage, and cascaded circuits in small signal or linear operations.

Physical Theory of New Circuit Representation for Junction Transistors. Jakob Zawels. *J. Appl. Phys.*, Aug., 1954, p. 976. Derivation of an expression to place the mechanism of transistor action in evidence, with the circuit as a direct interpretation of the diffusion equation and the boundary conditions which include the effects of base-width modulation.

Semiconductors; Their Characteristics and Principles. T. R. Lawson, Jr. *Westinghouse Engr.*, Sept., 1954, p. 178.

Theory of Dislocations in Germanium. W. T. Read, Jr. *Philos. Mag.* (*7th Ser.*), Aug., 1954, p. 775. 15 refs. Quantitative study of the electrical effects of dislocations in semiconductors.

Equipment

Electric

Electric Controls. III—A-C Motor Control. John C. Ponstingl. *Tool Engr.*, Sept., 1954, p. 51, folded chart. Detailed analysis of fundamental principles, design, applicational requirements, and relative merits of different systems, including features of motor starters, speed controls, and braking methods.

Electrical Contacts. I. F. J. Spayth. *Elec. Mfg.*, Sept., 1954, p. 92. Analysis of such factors as resistance, metal transfer, and energy dissipation in terms of miniaturization and other requirements.

Hydraulic & Pneumatic

Present Status of Cavitation Research. Robert T. Knapp. *Mech. Eng.*, Sept., 1954, p. 731. Review of investigations on the effect of cavitation on performance of hydraulic devices and on the losses from mechanical and corrosive damage.

Trends in British Aircraft Pumps. John A. Lankester. *Appl. Hydraulics*, Aug., 1954, p. 56. Design, operational characteristics, and requirements of radial and axial piston types for high-pressure hydraulic systems.

Fuels & Lubricants

Effects of Halocarbons on Engine Performance. Fred G. Rounds and John D. Caplan. *Ind. & Eng. Chem.*, Aug., 1954, p. 1677. 17 refs. Experimental investigation of additives related to combustion "knock" factors affecting power output.

Properties of Hydrogen Peroxide. J. A. Williams. *The Aeroplane*, Aug. 6, 1954, p. 189. Appraisal of relative merits and operational factors, including availability, handling, storage, and aircraft design needs.

Lubricants & Lubrication

Bearings, Lubricants, and Lubrication; A Digest of 1953 Literature. *Mech. Eng.*, Sept., 1954, p. 739. 136 refs. With a comprehensive bibliography.

The Boundary Friction of Very Well Lubricated Surfaces. E. Rabinowicz. **Commentary.** M. B. Peterson and E. E. Bisson. *Lubrication Eng.*, July-Aug., 1954, pp. 205, 230. 10 refs. Experi-

mental analysis of the frictional forces, including the shearing forces within a lubricant film.

The Development of Synthetic Lubricants for Aircraft Gas Turbines. D. W. Bedell. *Esso Air World*, July-Aug., 1954, p. 10. Analysis of quality requirements, operating conditions, and experience data.

Effects of Chemically Active Additives on Boundary Lubrication of Steel by Silicones. S. F. Murray and Robert L. Johnson. *U. S., NACA TN 3257*, Aug., 1954. 24 pp. 10 refs.

Gear-Tooth Lubrication. W. A. Tuplin. *Mach. Des.*, Aug., 1954, p. 125. Analysis of the factors concerned with the slide-sweep ratio concept.

Limiting Bulk Fluid Temperatures for Effective Boundary Lubrication by Synthetic Lubricants. S. F. Murray, R. L. Johnson, and E. E. Bisson. *Lubrication Eng.*, July-Aug., 1954, p. 193. 19 refs. Relative results of experimental investigations with particular reference to the conditions of load and speed as studied under special laboratory methodology.

The Reaction of Absorbed Stearic Acid with Copper and Copper Oxide. A. Dobry. *Lubrication Eng.*, July-Aug., 1954, p. 210. 12 refs.

Gliders

The Slingsby Type 37 Sailplane; Some Details of an Inexpensive Glider with Laminar-Flow Wings. T. A. Brown. *Aircraft Eng.*, Aug., 1954, p. 264.

Ice Formation & Prevention

Kinetic Treatment of the Nucleation in Supersaturated Vapors. R. Becker and W. Döring. (*An. d. Phys.* [Germany], No. 24, 1935, p 719.) *U.S., NACA TM 1374*, Sept., 1954. 43 pp. Translation.

The Occurrence of Ice Crystals in the Free Atmosphere. G. J. Day. *Meteorological Mag.*, Aug., 1954, p. 230.

On the Measurement of the Properties of Supercooled Clouds. K. G. Pettit. *Canada, NAE Rep. 2 (Quart. Bul.)*, 1954, p. 1. Experimental investigation at the NAE Low Temperature Lab. to form a basis for design criteria for aircraft icing protection systems.

Instruments

An Automatic Recording Potentiometer for Industrial Use. H. J. Roosdorp. *Philips Tech. Rev.*, Jan., 1954, p. 189. Design details of an instrument based on the null principle to measure d.c. voltages, resistances, and impedances, and with suitable transducers, to record temperature, pressure, force rates of flow, and other non-electrical quantities.

The Construction, Operation and Performance of a Primary Standard Mercury Column for the Measurement of High Pressures. K. E. Bett, P. F. Hayes, and D. M. Newitt. *Philos. Trans. Royal Soc. (London), Ser. A*, Aug. 10, 1954, p. 59. 58 refs.

Numerical Calculation of the End-Effect of Cylinders, Used as Measuring Element in Load-Cells. M. Kuipers. *Appl. Sci. Res., Sect. A*, No. 5-6, 1954, p. 337. Design and operational analysis of the strain-measuring device; applications and other factors.

Optimum Airspeed Selector. Paul B. MacCready, Jr. *Sailplane & Glider*, July-Aug., 1954, p. 7. Theoretical principles, design, and operational application of a simple glideflight indicator.

Thrust Measurement in Flight. J. D. Humphreys. *Aero. Dig.*, Sept., 1954, p. 50. Design and applicational method of a jet thrust calibration instrument.

Experience with Immersion Thermo-Couples. Gerhardt Eichert. (*Stahl und Eisen* [Düsseldorf], No. 2, 1954, p. 95.) *Gt. Brit., MOS TIB T4335*, July, 1954. 9 pp. Translation. Details of the high-temperature measuring apparatus featuring platinum-rhodium platinum elements, with experimental tests and working data.

Some Effects of Exposure to Exhaust-Gas Streams on Emittance and Thermoelectric Power of Bare-Wire Platinum Rhodium-Platinum Thermocouples. George E. Glawe and Charles E. Shepard. *U.S., NACA TN 3253*, Aug., 1954. 30 pp. 10 refs. Experimental research in high-temperature measurements for development of instrumentation.

Flow-Measuring Devices

Temperature-Compensated Aircraft Fuel Gage. Robert J. Levine. *Electronics*, Sept., 1954, p. 160. Design for accurate measurement of fuel quantity utilizing a compensating capacitor.

The Use of Primary Elements in Measurement of Flow. I. Henry W. Stoll. *Taylor Tech.*, Spring, 1954, p. 18. Review of basic principles and applications of the volumetric, area, differential, momentum, electromagnetic, and radiation techniques.

Viscous Effects on Pitot Tubes at Low Speeds. F. A. Macmillian. *J. RAeS*, Aug., 1954, p. 570.

Machine Elements

Bearings, Lubricants, and Lubrication; A Digest of 1953 Literature. *Mech. Eng.*, Sept., 1954, p. 739. 136 refs. With a comprehensive bibliography.

Comparative Investigation at Fluctuating Tension (R=O) on Dural Lugs of Different Design. A. Hartman. *Netherlands, NLL Rep. M. 1932*, Oct. 28, 1953. 20 pp. Tests to determine the influence on the fatigue strength of the static design criteria.

Graphical Method Speeds Design of Right-Angle Helical Gears. Donald M. Marshall. *Mach. Des.*, Aug., 1954, p. 175.

Manufacturing Methods of Power-Transmission Gears and Their Influence on Design Considerations. Dietrich W. Botstiber. *Mech. Eng.*, Sept., 1954, p. 735.

A Rotating Disc in Constant Pure Shear. S. Kumar and C. V. Joga Rao. *J. Indian Inst. Sci. Sect. B*, July, 1954, p. 102.

Materials

Aluminized Coatings; A Comparison of Hot-dip Coating with Aluminum and Hot Galvanizing. A. G. Thomson. *Aircraft Eng.*, Aug., 1954, p. 266.

Investigations into the Metal-Spraying Process. A. Matting and K. Becker. (*Schweissen und Schneiden* [Germany], Apr., 1954, p. 127.) *Engr. Dig.*, Aug., 1954, p. 309. Summary of results of studies at the Industrial Materials Research Inst., Hanover Tech. U.

Mechanical Properties at Room Temperature of Four Cermets of Titanium Carbide with Nickel Binder. Aldie E. Johnson, Jr. *U.S., NACA TN 3197*, Aug., 1954. 22 pp. Analysis and tabulation of the values of ultimate strength, modulus of elasticity, modulus of rigidity, Poisson's ratio in the elastic region, density, and hardness.

Metals & Alloys

The Challenge to the Metallurgist of Design in Gas-turbine and Airframe Development. *Metal Treatment*, July, 1954, p. 325.

A Dictionary of Metallurgy. XXIV—*Mo-Ne*. XXV—*Ne-Ni*. A. D. Merriman and J. S. Bowden. *Metal Treatment*, July, Aug., 1954, p. 317, 369.

Relations Between the Elastic Moduli and the Plastic Properties of Polycrystalline Pure Metals. S. F. Pugh. *Philos. Mag. (7th Ser.)*, Aug., 1954, p. 823. 29 refs.

Austenitic Grain Size Measurement of Steels; Improvement of the Oxidation Method of Determination. A. Kohn. *Metal Treatment*, Aug., 1954, p. 359. 10 refs.

Stainless Steels In Brief. I—Roles Of The Common Alloys. Richard E. Paret. *Steel Processing*, Aug., 1954, p. 500.

Metals & Alloys, Nonferrous

Additional Static and Fatigue Tests of High-Strength Aluminum-Alloy Bolted Joints. E. C. Hartmann, Marshall Holt, and I. D. Eaton. *U.S., NACA TN 3269*, July, 1954. 42 pp. Extension of investigation reported in NACA TN 2276 on 75S-T6, 24S-T4, and 14S-T6 extruded aluminum alloys.

Aluminium Alloys containing Beryllium (With an Appendix with regard to Silicon-Beryllium Alloys). Georg Masing and Otto Dahl. (*Siemenstadt, Mitt. Forsch. Lab.* [Germany], 1929, p. 248.) *Gt. Brit., MOS TIB T4359*, July, 1954. 7 pp. Translation.

The Effect of Stress Concentrations of the Fatigue Resistance of 24ST Aluminium Alloy. J. Y. Mann. *Australia, ARL Rep. SM. 217*, Nov., 1953. 64 pp. 26 refs.

Investigation of Nickel-Aluminum Alloys Containing from 14 to 34 Percent Aluminum. W. A. Maxwell and E. M. Grala. *U.S., NACA TN 3259*, Aug., 1954. 42 pp. 13 refs. Exploratory study of the properties of intermetallics.

Magnesium Alloys for Elevated Temperature Applications. *Mag. of Magnesium*, Aug., 1954, p. 13. Detailed analysis of tensile and other properties as applied in jet engines and airframes, with charts and tables.

Titanium Technology in Mid-1954. H. T. Clark, J. P. Catlin, and W. E. Gregg. *Mech. Eng.*, Sept., 1954, p. 716. Appraisal of properties, applications, and fabricational techniques.

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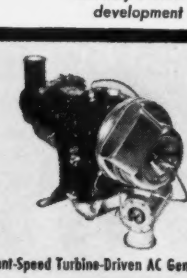

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Nonmetallic Materials

Crystallization Phenomena in Polymers. I—Preliminary Investigation of the Crystallization Characteristics of Polyethylene Terephthalate. A. Keller, G. R. Lester, and L. B. Morgan. **II—The Course of the Crystallization.** L. B. Morgan. **III—Effect of Melt Conditions and the Temperature of Crystallization on the Course of the Crystallization in Polyethylene Terephthalate.** F. D. Hartley, F. W. Lord, and L. B. Morgan. *Philos. Trans. Royal Soc. (London), Ser. A*, Aug. 10, 1954, pp. 1, 13, 23. 16 refs.

The Effect of Temperature on the Strength of Wood, Plywood and Glued Joints. P. H. Sulzberger. *Australia, Aero. Res. Consultative Comm. Rep. ACA-46*, Dec., 1953. 44 pp. 20 refs. CSIR experimental investigation of reversible properties related to temperature variations.

Effects of Resin Coating Methods and Other Variables on Physical Properties of Glass-Fabric Reinforced Polyesters. B. M. Axilrod, J. E. Wier, and J. Mandel. *U.S., NACA RM 54G26*, Aug. 23, 1954. 22 pp.

Unsaturated Polyester Resins; Symposium at the 124th ACS Meeting, Chicago, 1954. *Ind. & Eng. Chem.*, Aug., 1954, p. 1612. 50 refs. Partial contents: Applications and Uses, Arthur L. Smith. Physical Properties of Polyester Resins, Earl E. Parker and E. W. Moffett. Flame-Resistant Polyesters from Hexachlorocyclopentadiene, P. Robitschek and C. Thomas Bean. Polyester Resin-Glass Fiber Laminates, Johan Bjorksten, L. L. Yaeger, and J. E. Henning. Thermal Properties of Polyester Resins, T. E. Bockstahler, G. E. Forsyth, J. J. Gouza, F. R. Shirak, and E. M. Beavers.

Silicone Rubber Progress. B. B. White and D. P. Spalding. *Aero Dig.*, Aug., 1954, p. 54. Developmental review of properties, relative merits, applications, and potentialities.

Testing

De Afscheurproef van Gelijmd Lichtmetaalplaat. I. A. Hartman. *Netherlands, NLL Rep. M. 1940*, 1954. 49 pp. In Dutch. Results of the Aero Research peeling tests as part of an extensive investigation into the strength and other mechanical properties of glued joints.

Correlation of Polarized Light Phenomena With the Orientation of Some Metal Crystals. C. J. Newton and H. C. Vacher. (*Res. Paper 2510.*) *U.S., NBS J. Res.*, July, 1954, p. 1. 20 refs. Metallographic studies with tin, aluminum, and monel specimens.

High-Resolution Autoradiography. George C. Towe, Henry J. Gomberg, and J. W. Freeman. *U.S., NACA TN 3209*, July, 1954. 138 pp. 101 refs. Adaptation of the wet-process radiographic technique to the study of metallic microstructures to anticipate severe temperature and stress conditions in aircraft propulsion systems, with a comprehensive bibliography.

Penetration of Thick Steel Samples by Betatron Apparatus. M. Komers. (*Stahl und Eisen* [Düsseldorf], No. 11, 1953, p. 713.) *Gt. Brit., MOS TIB T4227*, June, 1954. 14 pp. Translation. Developmental survey of fundamental principles, equipment requirements, potentialities, and applications to nondestructive testing.

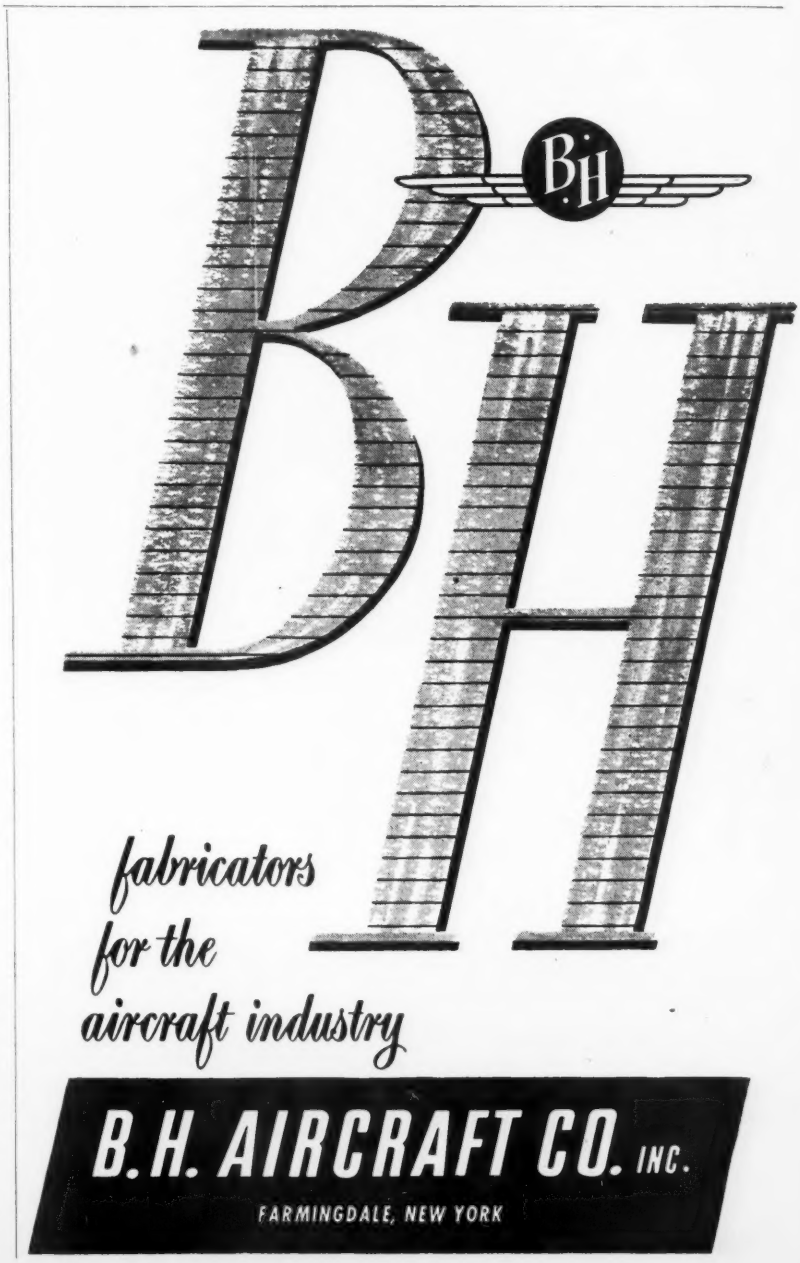
Triaxial Stresses Caused by Notches. A. F. C. Brown. *Brit. J. Appl. Phys.*, Aug., 1954, p. 280. Stress analyses by the photoelastic frozen stress method on round bars with circumferential notches and tensile tests on steel specimens to provide data for brittleness testing as a means of suppressing deformation in ductile materials.

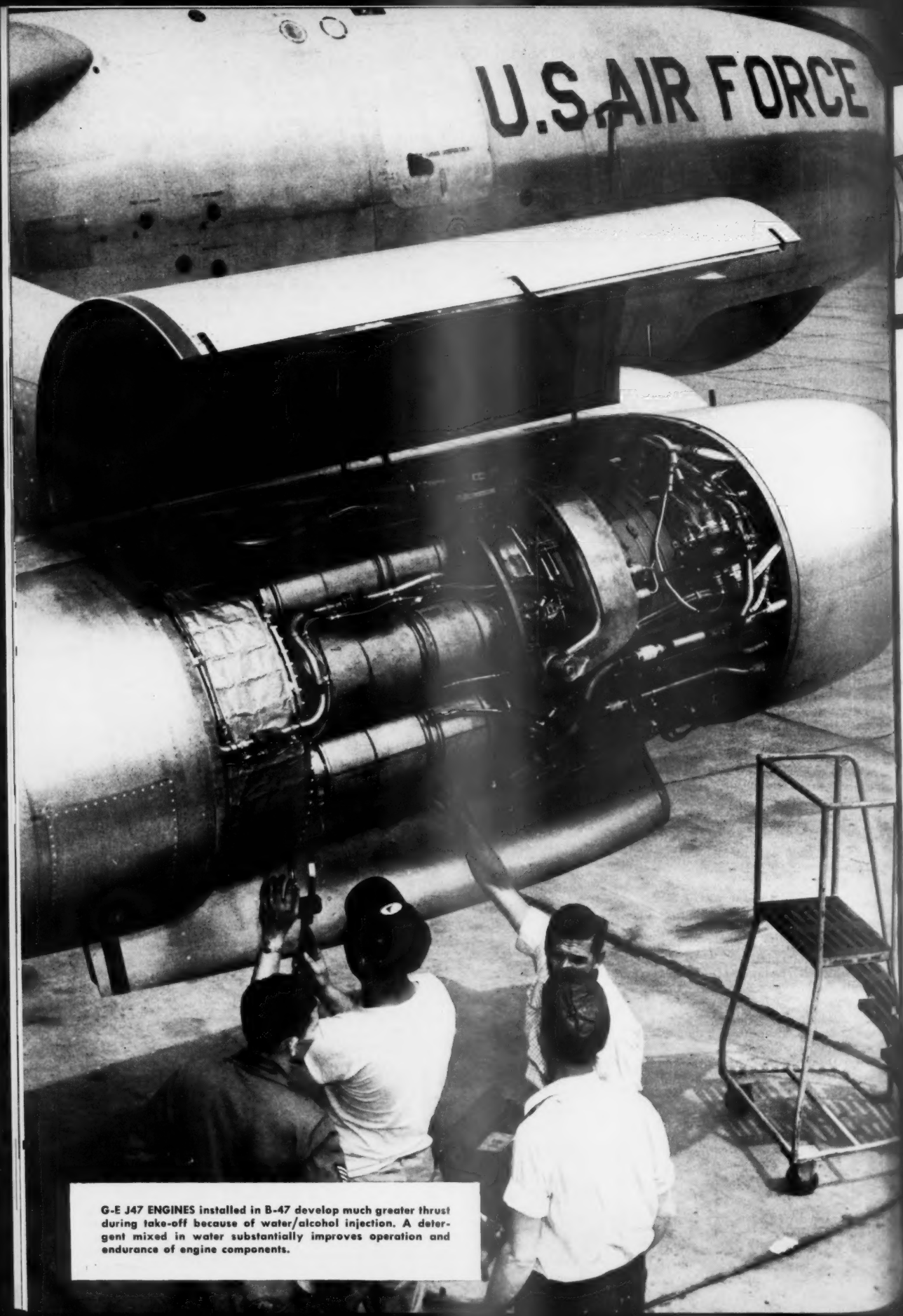
Mathematics

An Extended Use of Perturbation Theory. R. N. Gould and A. Cunliffe. *Philos. Mag. (7th Ser.)*, Aug., 1954, p. 818. Determination of the solution of a partial differential equation: $(H + U)\,\phi = 0$ in terms of the solution of another partial differential equation: $H\,\theta = 0$ and the eigen-functions of a third equation: $H\psi = \lambda\psi$.

Further Statistical Problems Connected with the Solution of a Simple Non-linear Partial Differential Equation. J. M. Burgers. *Netherlands, Koninklijke Nederlandse Akademie van Wentenschappen, Proc. Ser. B*, No. 2, 1954, p. 159. Reprint.

On the Coalescence of Wave like Solutions of a Simple Non-linear Partial Differential Equation. I, II. J. M. Burgers. *Netherlands, Koniklijke Nederlandse Akademie van Wentenschappen, Proc. Ser. B*, No. 1, 1954, pp. 45, 57. Reprint.





G-E J47 ENGINES installed in B-47 develop much greater thrust during take-off because of water/alcohol injection. A detergent mixed in water substantially improves operation and endurance of engine components.

TWO METHODS USED TO AUGMENT THRUST IN JET ENGINES

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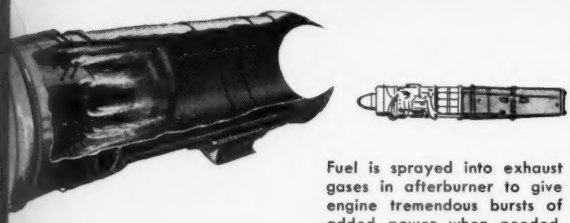
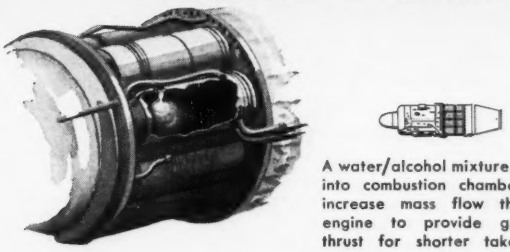


Fuel is sprayed into exhaust gases in afterburner to give engine tremendous bursts of added power when needed

WATER/ALCOHOL INJECTION



A water/alcohol mixture is fed into combustion chambers to increase mass flow through engine to provide greater thrust for shorter take-offs.

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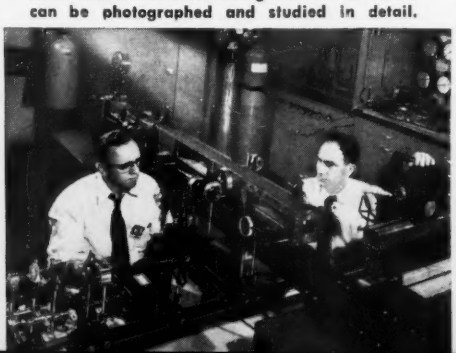

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On the Coefficients of the Modular Invarient $J(\tau)$. A. van Wijngaarden. (*Netherlands, Mathematisch Centrum, Amsterdam, Rep. R 122*, 1953.) *Netherlands, Koninklijke Nederlandse Akademie van Wentenschappen, Proc. Ser. A*, No. 4, 1953, p. 389. Reprint.

Statistical Concepts in Theoretical Physics. R. Furth. *Brit. J. Appl. Phys.*, Aug., 1954, p. 273. Appraisal of applications and basic principles.

Meteorology

Clear-Air Turbulence and Mountain Waves: Correlation of Theory with Pilots' Experience. R. S. Scorer. *Flight*, Aug. 20, 1954, p. 233.

The Estimation of Cloud Parameters by Radar. David Atlas. *J. Meteorology*, Aug., 1954, p. 309. 21 refs. Study at the USAF Cambridge Research Center.

The Life Cycles of Jet Streams and Extratropical Cyclones. Joseph Vederman. *Bul. AMS*, June, 1954, p. 239. 10 refs.

The Meridional Growth of Squall Lines. Abdul J. Abdullah. *J. Meteorology*, Aug., 1954, p. 301. USAF-sponsored study at NYU of the properties, formation, and growth of a squall line, with a derivation of a formula to forecast the growth.

Meteorological Factors Affecting the Operation of Jet Aircraft. M. S. V. Rao. *Indian AF Quart.*, July, 1954, p. 30.

On Gravity Waves in the Atmosphere. Earl Gossard and Walter Munk. *J. Meteorology*, Aug., 1954, p. 259. ONR-supported investigation at La Jolla, Calif.

Rocket-Borne Photometer Measures Sky Light. A. Corman and J. F. Bedinger. *Electronics*, Sept., 1954, p. 151. USAF development as part of studies of atmospheric properties at high altitudes.

Military Aviation

Application of Operations-Research Techniques to Air-Borne Weapon System Planning. Robert A. Bailey. *Aero. Eng. Rev.*, Oct., 1954, p. 72. Lockheed Aircraft Corp. experience.

"New Look" in Weapons Planning. IV—Water-Based Interceptors. V—Radar Problems, Yesterday and Today. Th. Pederzani. **VI—Fire Control Equipment for Light Anti-Aircraft Artillery.** D. G. H. Brethouwer. **VII—Anti-Aircraft Tanks versus Ground Attack Aircraft.** Seherr-Thoss. **VIII—New Anti-Aircraft Guns and Fire Control Equipment. IX—Packaged Bombers.** *Interavia*, No. 8, 1954, p. 534.

Special Issue: (USAF) Air Material Command Edition. *Av. Week*, Aug. 16, 1954. 406 pp. Partial contents: AMC Planners Phase Weapons Systems. Electronics to Streamline AF Logistics. Keeping Them Flying Is Big Business. USAF Procurement Program.

Missiles

Economizing in Missile Design. Jesse Steinman. *Western Av.*, Aug., 1954, p. 6. Free-flight phase requirements in design procedures, with diagrams.

A Guided-missile Design Study. *The Aeroplane*, Aug. 6, 1954, p. 198. Analysis of a hypothetical research problem at the College of Aeronautics, Cranfield.

Problems of Manoeuvrability in Interception by Missiles. R. Cox Abel. *Aeronautics*, Aug., 1954, p. 20. Analytical and diagrammatic critique of various aspects in the estimation of the radial accelerations of a guided missile and of a bomber in an intercept-tracking operation.

Project Nike. W. H. C. Higgins. *Ordnance*, Sept.-Oct., 1954, p. 227. Appraisal of the design conception, planning, and development of the rocket-powered, surface-to-air, high-speed guided missile.

Navigation

Navigation at Different Speeds—a Comparative Study. S. Vasudev. *Indian AF Quart.*, July, 1954, p. 43.

Noise Reduction

Some Aspects of the Helicopter Noise Problem. Harvey H. Hubbard and Leslie W. Lassiter. *U.S., NACA TN 3239*, Aug., 1954. Appraisal of the nature and characteristics of the problem and tentative criteria for evaluating it.

Photography

Calculation of Camera Exposure. Parry Moon and Domina Eberle Spencer. *J.*

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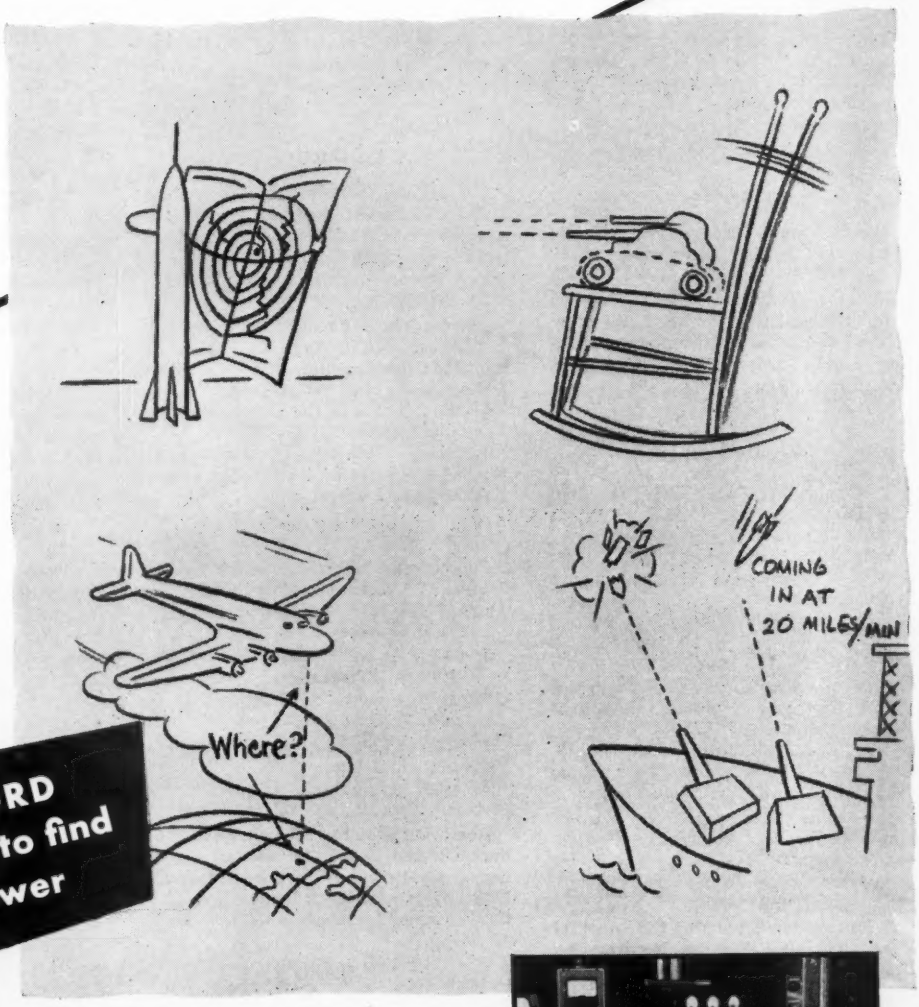

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Franklin Inst., Aug., 1954, p. 113. 41 refs. Review of basic principles and applications to scientific study.

Instrument Methods in Aerial Survey. Marc Sheldon and L. A. Dickerson. *Radio-Electronic Eng.*, Aug., 1954, p. 13. Use of combined airborne radar, helicopter, and photogrammetry techniques, with an evaluation of relative advantages.

Photographic Motion Analysis. V, VI. John H. Waddell and Jennie W. Waddell. *Ind. Labs.*, Aug., Sept., 1954, pp. 101, 67. The analysis includes a photographic ballistic study of missiles in flight.

Physics

Acoustic and Ultrasonic Relaxation Processes. E. G. Richardson. *Appl. Mech. Rev.*, Sept., 1954, p. 377. Brief review of the literature.

On the Relation Between Quantum Hydrodynamics and Conventional Quantum Field Theory. F. A. Kaempfer. *Can. J. Phys.*, Aug., 1954, p. 530.

Power Plants

The Choice of Power Units for Civil Aeroplanes. (The 42nd Wilbur Wright Memorial Lecture, May 20, 1954.) A. E. Russell. *J. RAeS*, Aug., 1954, p. 523. Analytical evaluation of fundamental factors facing airlines, including design, performance, and economic operation.

Jet & Turbine

Flame Stabilization in a Hot Gas Stream by the Upstream Air Blast Injection of Kerosene Fuel. N. Golitzine. *Canada, NAE LR-102*, May 10, 1954. 14 pp. Experimental investigation of jet engine thrust augmentation by exhaust reheat.

Jet-Engine Testing. R. D. Burdett and B. F. Burdick. *Instruments & Automation*, Aug., 1954, p. 1294. Equipment and techniques to solve nonsteady-state testing problems at G-E.

A Method for Evaluating the Effects of Drag and Inlet Pressure Recovery on Propulsion-System Performance. Appendix A—Derivation of Thrust Parameter for Air-Breathing Propulsion System. Appendix B—Evaluation of Variation of Internal Thrust with Inlet Pressure Recovery. Emil J. Kremzier. *U.S., NACA TN 3261*, Aug., 1954. 21 pp.

Spark Ignition of Flowing Gases. IV—Theory of Ignition in Nonturbulent and Turbulent Flow Using Long-Duration Discharges. Appendix—Effect of Turbulence on Energy Required to Ignite Propane-Air Mixture. Clyde C. Swett, Jr. *U.S., NACA RM E54F29a*, Aug. 19, 1954. 29 pp. 10 refs. Application of findings covering fundamental factors to the design and operation of jet-engine combustors.

Vibrations of Turbine Blades with Loose Hinge Support. Frithiof Niordson. (*Tekniska Skrifter*, No. 154, 1954.) *Acta Polytechnica (Stockholm), Mech. Eng. Ser.*, No. 3 (140), 1954. 11 pp. Development of a method to obtain the natural frequency of the fundamental bending mode, with a derivation of the equations of motion.

Rocket

Armstrong Siddeley Snarler; 2,000 lb. Maximum Thrust. *The Aeroplane*, Aug. 6, 1954, p. 180, cutaway drawings. Design and structural details, with operational and other technical data.

More about the Sprites. *The Aeroplane*, Aug. 6, 1954, p. 185. Design and developmental review, with technical specifications covering dimensions, weights, and performance; also includes comparative rocket data.

Production

Caravelle. I—Prototype-Manufacture and Production-Methods for the SE-210 Aircraft of Société Nationale de Constructions Aéronautiques du Sud-Est. James Hay Stevens. *Aircraft Prod.*, Sept., 1954, p. 348.

Special Issue: Commonwealth Aircraft Industries. *Flight*, Aug. 27, 1954. 133 pp. Partial contents: The Canadian Industry. Aircraft of the Commonwealth—1954. Missiles in the Commonwealth. The Commonwealth Air Forces. The Australian Industry. Commonwealth Engines—1954. Ancillary Companies. Commonwealth Directory.

Metalworking

Forging Of Aircraft Gas Turbine Blades. L. M. Raring. *Steel Processing*, Aug., 1954, p. 487. Developmental techniques and processes.

Heat-Treatment of High-Speed Steel. VII—Surface Treatments. VIII—Annealing Treatment. S. G. Cope. *Metal Treatment*, July, Aug., 1954, pp. 343, 361.

Precision Chucking of Thin-Walled Parts. K. W. Cole. *Tool Engr.*, Sept., 1954, p. 37. Application to fabricational problems of jet aircraft engines.

Removing Metal by Chemistry to Produce Difficult Shapes for Aircraft Structures; Controlled Etching of Aluminum Offers Design and Production Possibilities. Manuel C. Sanz. *Auto. Ind.*, Sept. 1, 1954, p. 54.

The Technique of Melting and Casting in High Vacuum. Otto Winkler. (*Stahl und Eisen* [Düsseldorf], Sept. 24, 1953, p. 1261.) *Gt. Brit., MOS TIB T4303*, July, 1954. 15 pp. Translation.

Tensioned-Skin Construction; Application of the Heal Method in the Building of the Accountant Aircraft; Wider Application of the Principle of Pre-Tensioning. *Aircraft Prod.*, Sept., 1954, p. 378.

Alloy Welds Deposited in "Unalloyed" Titanium Base Metal. II. Appendix—Literature on the Effect of Carbon, Oxygen, Hydrogen and Nitrogen on the Structure and Properties of Iodide and Commercially Pure Titanium. C. E. Hartbower and Daniel M. Daley, Jr. *Welding J. Res. Suppl.*, Aug., 1954, p. 401-s. 16 refs. Investigation including a study of notched-bar impact testing to develop a method for improving the toughness and strength of weld joints.

The Effect of Welding Variables on Hard-Facing Deposits. A. Zvanut and V. Peters. *Welding J.*, Aug., 1954, p. 778.

Effects of Oxygen and Nitrogen in Welding Titanium Alloys. James H. Johnston. *Welding J. Res. Suppl.*, Aug., 1954, p. 414-s.

Effects of Temperature on Weld Metal Properties. J. Heuschkel. *Welding J. Res. Suppl.*, Aug., 1954, p. 388-s.

New Principles for the Calculation of Welded Joints. C. G. J. Vreedenburgh. *Welding J.*, Aug., 1954, p. 743. 10 refs. Development of a method based on an empirically determined limit curve.

Resistance Welding in Jet Engine Manufacturing. F. J. Wallace. *Welding J.*, Aug., 1954, p. 762. Pratt & Whitney operational experience with equipment, design factors, materials, quality control, and tools.

Spot Welding of High-Strength Aluminium Alloys; Effects of Welding Variables on Weld Quality. H. E. Dixon and J. E. Roberts. *Brit. Welding J.*, Aug., 1954, p. 351. 14 refs.

The Spot Welding of Titanium. E. R. Funk. *Welding J. Res. Suppl.*, Aug., 1954, p. 397-s. Analysis of physical properties using different settings and thicknesses of material based on Goodyear Aircraft experience.

Spot Welding Thin Aluminum. I. W. Johnson. *Welding J.*, Aug., 1954, p. 759. Use of an "up-down slope control" device in conjunction with standard single-phase equipment.

Submerged Arc Welding of Chromium-Bearing Steels. Clarence E. Jackson and Arthur E. Shrubsall. *Welding J.*, Aug., 1954, p. 752.

Welding Aluminum Sheet. F. C. Geibig. *Welding J.*, Aug., 1954, p. 784. Appraisal of the oxy-acetylene process.

The Welding of Heavy Sections. W. Spraragen and M. A. Cordovi. *Welding J. Res. Suppl.*, Aug., 1954, p. 369-s. 18 refs. Review of the literature covering basic principles and problems of such factors as preheating, peening, intermediate stress relieving, and of specialized equipment and techniques, with a detailed summary table.

Welding Procedure for Welding Tubes in Heat Exchangers. W. E. Battles. *Welding J.*, Aug., 1954, p. 739.

Weldments in the Titanium-Manganese Sheet Alloy RC-130A. H. M. Meyer. *Welding J. Res. Suppl.*, Aug., 1954, p. 417-s.

Production Engineering

The Practical Application of the New British Standard System of Limits and Fits. G. J. Pearmain. *IME Proc.*, No. 8, 1954, p. 246.

Sampling Plans Reduce Inspection Time. Martin H. Saltz. *Tool Engr.*, Sept., 1954, p. 45. Hughes Aircraft Co. experience in quality control procedures.

A Systematic Method for Analyzing and Assigning Practical Tolerances. E. T. Fortini. *Mach. Des.*, Aug., 1954, p. 117. Appraisal of the "dimension study" process, with illustrative applications.

Technical Features of the New British Standard System of Limits and Fits. H. G. Conway. *IME Proc.*, No. 8, 1954, p. 233.

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Reference Works

Bearings, Lubricants, and Lubrication; A Digest of 1953 Literature. *Mech. Eng.*, Sept., 1954, p. 739. 136 refs. With a comprehensive bibliography.

High-Resolution Autoradiography. George C. Towe, Henry J. Gomberg, and J. W. Freeman. *U.S., NACA TN 3209*, July, 1954. 138 pp. 101 refs. Adaptation of the wet-process radiographic technique to the study of metallic microstructures to anticipate severe temperature and stress conditions in aircraft propulsion systems, with a comprehensive bibliography.

Special Issue: Commonwealth Aircraft Industries. *Flight*, Aug. 27, 1954. 133 pp. Partial contents: The Canadian Industry. Aircraft of the Commonwealth—1954. Missiles in the Commonwealth. The Commonwealth Air Force. The Australian Industry Commonwealth Engines—1954. Ancillary Companies. Commonwealth Directory.

Special Issue: (USAF) Air Material Command Edition. *Av. Week*, Aug. 16, 1954. 406 pp. Partial contents: AMC Planners Phase Weapons Systems. Electronics to Streamline AF Logistics. Keeping Them Flying Is Big Business. USAF Procurement Program.

Rotating Wing Aircraft

Helicopter Flight Experience with Continental XT-51 Fixed Shaft Turbine. I. Ralph P. Alex. (*SAE Summer Meeting Atlantic City, N.J., June 6–11, 1954, Paper.*) *Am. Helicopter*, July, 1954, p. 8.

Reduction of Helicopter Parasite Drag. Robert D. Harrington. *U.S., NACA TN 3234*, Aug., 1954. 8 pp. 10 refs. Design appraisal of possible benefits for high speed and long range and means of parasitic drag reduction.

Rotors & Blades

A General Theory of Helicopter Rotor Dynamics; An Analysis of the Dynamics of a Helicopter Rotor with Tapered and Twisted Blades. P. R. Payne. *Aircraft Eng.*, Aug., 1954, p. 247.

Hovering Performance of a Helicopter Rotor Using NACA 8-H-12 Airfoil Sections. Robert D. Powell, Jr., *U.S., NACA TN 3237*, Aug., 1954. 14 pp.

Rapid Estimation of Bending Frequencies of Rotating Beams. Robert T. Yntema. *U.S., NACA RM L54G02*, Aug. 18, 1954. 18 pp. Graphical procedure of frequency determination based on the Southwell equation for such factors as higher modes, offset, and variable mass and stiffness distributions of helicopter rotor blades.

Review of Information on Induced Flow of a Lifting Rotor. Alfred Gessow. *U. S., NACA TN 3238*, Aug., 1954. 16 pp. 28 refs. Survey of the available literature covering theoretical and experimental investigations on the inflow distribution for helicopter analyses.

Wind-Tunnel Studies of the Performance of Multirotor Configurations. Richard C. Dingeldein. *U.S., NACA TN 3236*, Aug., 1954. 10 pp. Experimental tests on coaxial and tandem systems, with

emphasis on the problems of power requirements in hovering and in level flight.

Safety

Airplane Design and Safety. R. W. Rummel. *Skyways*, Aug., 1954, p. 9. Appraisal of fundamental design principles for safe operation.

Structures

Measured Deflections and Twist of a 45° Swept Rectangular Tube. N. B. Joyce. *Australia, ARL Rep. SM. 223*, Jan., 1954. 36 pp. Investigation based on the beam theory utilizing a simplified structure of the problems of estimating critical speeds in terms of the flexibility influence coefficients of a deflected swept wing.

A Nonlinear Theory of Bending and Buckling of Thin Elastic Shallow Spherical Shells. A. Kaplan and Y. C. Fung. *U.S., NACA TN 3212*, Aug., 1954. 58 pp. 10 refs. Theoretical and experimental investigation of the problem of finite displacement and other factors.

The Service Life of Aircraft Structures; An Examination from a Statistical Viewpoint of the Fundamentals upon which Aircraft Stressing is Based. F. Turner. (*Saab Sonics*, No. 20, 1954, p. 14.) *Aircraft Eng.*, Aug., 1954, p. 260. 16 refs.

Stress Distributions Caused by Three Types of Loading on a Circular Semimonocoque Cylinder with Flexible Rings. Harvey G. McComb, Jr. *U.S., NACA TN 3199*, Sept., 1954. 54 pp.

Test Development of Structures Designed Understrength. John H. Meyer. *Aero. Eng. Rev.*, Oct., 1954, p. 54. An appraisal of the stretch-testing technique to obtain benefits of weight-saving, with an approximate criterion for the value of weight factors.

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The Application of Membrane Analogy for the Determination of Torsional Rigidity of Non-circular Solid Shafts. V. Cadambe and R. K. Kaul. *J. Sci. & Ind. Res., Sect. B*, July, 1954, p. 455.

Maximum Shear Stress. A. R. Holowenko and H. G. Laughlin. *Mach. Des.*, Aug., 1954, p. 159. Clarification of misconceptions in the calculation of the stress at a point for biaxial loading as in the cases of a thin-walled air cylinder showing longitudinal and hoop stresses and a turbine rotor showing radial and circumferential stresses.

Transient Wave Analysis in a Linear Time-Dependent Material. R. D. Glauz and E. H. Lee. *J. Appl. Phys.*, Aug., 1954, p. 947. NAVORD-sponsored investigation of a body exhibiting an elastic, a viscous, and a retarded elastic response when subjected to stress; analysis of the particular case of a semi-infinite bar with a constant velocity applied at an end in which the transient stresses, strains, and velocities are determined by the method of characteristics.

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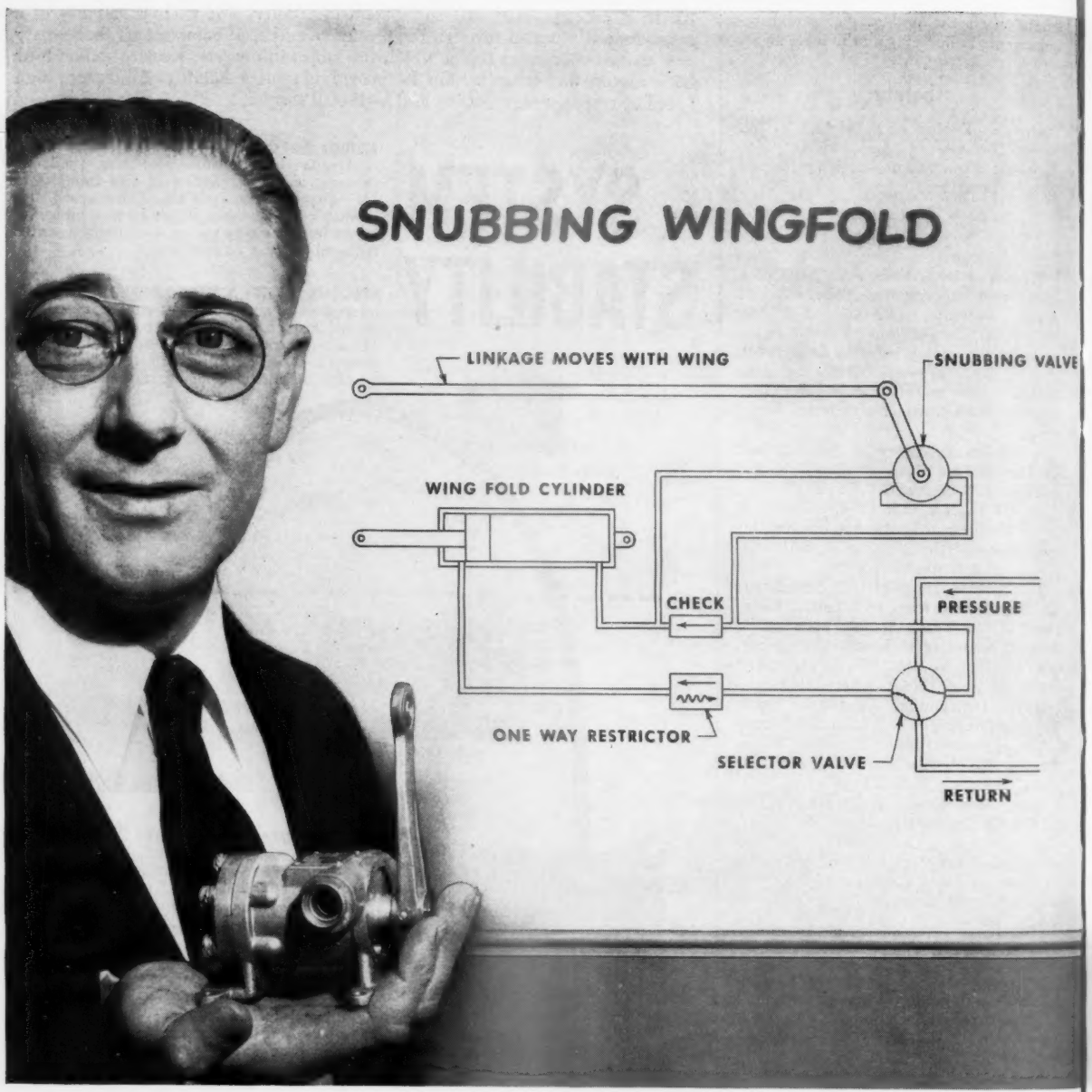

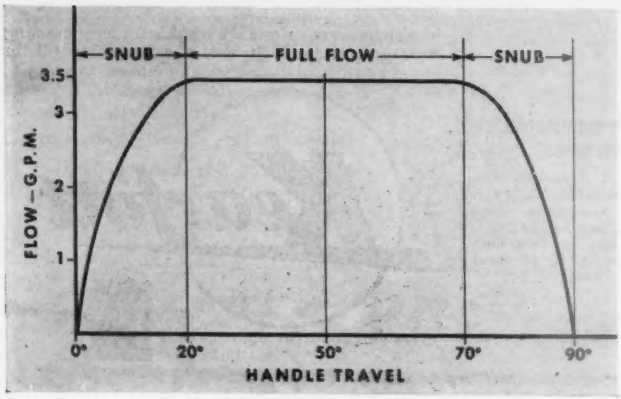

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Evaluation of Stresses in a U-Shaped Member by the Shear Difference Method. C. L. Amba Rao and S. R. Telang. *J. Indian Inst. Sci., Sect. B*, July, 1954, p. 95. Use of an experimental and graphical integrative technique to develop the analysis.

Optimum Design of Indeterminate Frames. William B. Readey. *J. Aero. Sci.*, Sept., 1954, p. 615. Development of a method to obtain the optimum section property distribution directly from design conditions.

Plastic Deformation in Beams. Y. V. G. Acharya and G. Janaki Ram. *J. Aero. Soc. India*, May, 1954, p. 32. Qualitative analysis of the theoretical basis applied to cases of bending and shear and related to the concept of surface of discontinuity, with hydrodynamic analogs.

Tapered Beams under Distributed Flank Loads; Solutions of Two-dimensional Loading Problems on an Infinite Wedge. D. E. R. Godfrey. *Aircraft Eng.*, Aug., 1954, p. 240.

Testing of Columns with Uniformly Distributed Transverse Loads. Paul C. Paris. *Eng. J.*, Aug., 1954, p. 945. Experimental verification of the Van den Broek beam-column formula, with potential application to cases of nonuniformly distributed transverse loadings.

Torsional Vibrations of Hollow Thin-Walled Cylindrical Beams. Edwin T. Kruszewski and Eldon E. Kordes. *U.S., NACA TN 3206*, Aug., 1954. 33 pp. Derivation of general solutions, based on appropriate differential equations and boundary conditions, for the modes and frequencies of cantilever and free-free cylindrical beams of arbitrary doubly symmetrical cross section with uniform wall thickness.

Plates

Behaviour in Pure Bending of Box Girders. J. C. Chapman. *The Engr.*, Aug. 20, 1954, p. 253. Results of a general experimental investigation to study the effect of buckling in the webs without the added complication of flange buckling, with a theoretical analysis of an initially flat rectangular plate sustaining end forces which vary linearly from compression at one edge to an equal tension at the other.

Circular Plates Subjected to Radially Symmetrical Transverse Load Combined with Uniform Compression or Tension in the Plane of the Plate. Ove Pettersson. (*Tekniska Skrifter*, No. 153, 1954.) *Acta Polytechnica (Stockholm), Mech. Eng. Ser*, No. 1 (138), 1954. 31 pp. 13 refs.

Symmetrical Buckling of Right-Angled Isosceles Triangular Plates. W. H. Wittrick. *Aero. Quart.*, July, 1954, p. 131.

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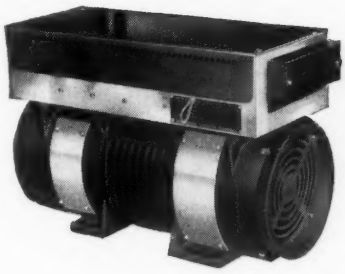

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				3	250			
12142	27.5	22	115	1	250	13	35000	N-17158 Navy
				3	250			
12146-1	27.5	22	115	1	250	13	35000	53B6239 AF
12146-3	27.5	22	115	1	250	13	35000	—
				3	250			
MG-60	27.5	22	115	1	250	17	50000	53B6239 AF
MG-62	27.5	22	115	3	250	17	50000	AN3532-2
32E01	27.5	35	115	1	500	25	50000	AN3533-1
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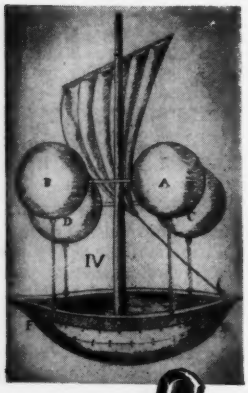

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The Effect of Latent Heat on Numerical Solutions of the Heat Flow Equation. P. H. Price and M. R. Slack. *Brit. J. Appl. Phys.*, Aug., 1954, p. 285.

On the Thermodynamics of Liquid Junction Potentials. T. G. Owe Berg. *Appl. Sci. Res., Sect. A*, No. 5–6, 1954, p. 421. 21 refs.

On the Thermodynamics of Mixtures. T. G. Owe Berg. *Appl. Sci. Res., Sect. A*, No. 5–6, 1954, p. 393.

Combustion

Application of Ideal Gas Theory to the Gaseous Expansion from an Electric Spark. R. B. Edmonson, H. L. Olsen, and E. L. Gayhart. *J. Appl. Phys.*, Aug., 1954, p. 1008. Results of the NAVORD-supported investigation applied to the study of the problem of spark ignition in combustible mixtures.

Determination of Flame Temperatures from 2000° to 3000°K by Microwave Absorption. Perry W. Kuhns. *U.S., NACA TN 3254*, Aug., 1954 48 pp. 16 refs. Experimental investigation covering: determination of the collision frequency of free electrons in a flame; the estimation of sensitivity of the attenuation measurement to variations in flame parameters such as temperature, flame size, gas flow, and salt concentration; the applicability of an instrument for the measurement of average flame temperatures and of time-fluctuating flame temperatures; and other physical and chemical factors.

Diffusion Flames in The Laboratory. John Barr. *NATO AGARD Memo. AG11/M7*, 1954. 11 pp. 52 refs. Review of the literature.

Equations of a Simple Flame Solved by Successive Approximations to the Solution of an Integral Equation. G. Klein. *U. Wis. NRL Dept. Chem. Rep. 8*, June 9, 1954. 24 pp.

The Flame Velocity in Steadily Burning Flames. E. Bartholomé. (*Naturwissenschaften* [Germany], No. 6–7, 1949, pp. 171, 206.) *Gt. Brit., MOS TIB T4283* Apr., 1954. 22 pp. 13 refs. Translation.

The Laminar Flame Speed of Propane/Air Mixtures with Heat Extraction from the Flame. J. P. Botha and D. B. Spalding. *Proc. Royal Soc.* (*London*), *Ser. A*, Aug. 6, 1954, p. 71. 25 refs.

A Study of the Radiation from Laminar and Turbulent Open Propane-Air Flames as a Function of Flame Area, Equivalence Ratio, and Fuel Flow Rate. Thomas P. Clark and David A. Bittker. *U.S. NACA RM E54F29*, Aug. 24, 1954. 33 pp.

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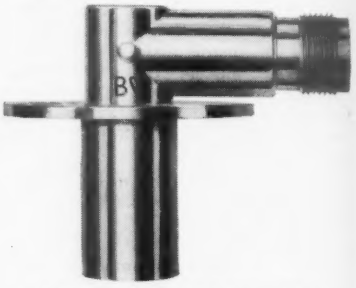

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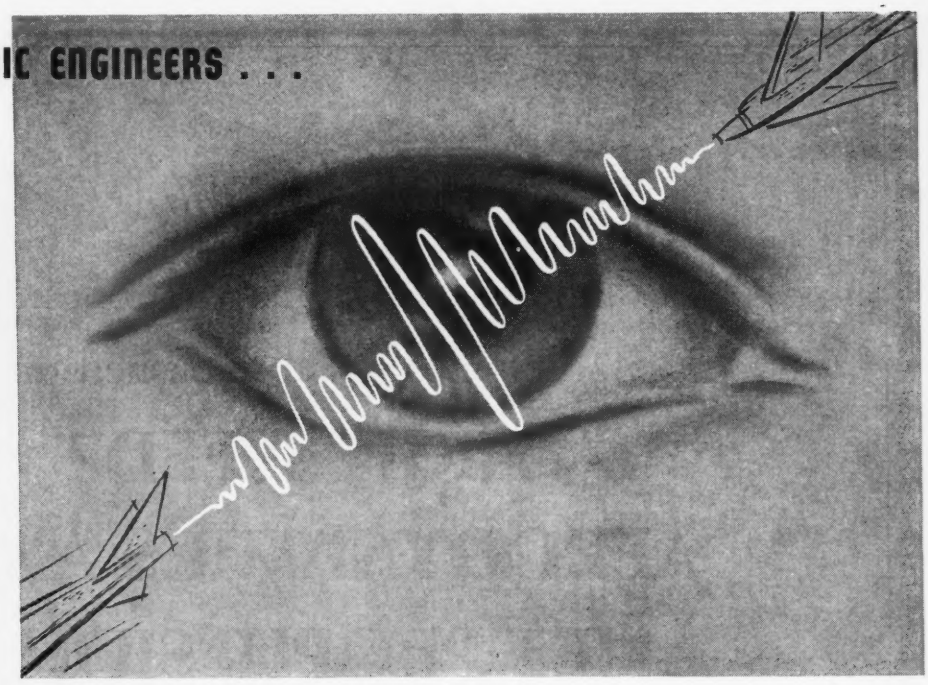

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ELECTRONICS

Proceedings of the National Electronics Conference, Volume 9. Chicago, September 28–30, 1953. Chicago, National Electronics Conference, Inc., February, 1954. 958 pp., illus., diagrs., figs. $5.00.

The 98 papers presented at this conference are classified under the following headings: General Papers. Circuits I. Magnetic Amplifiers. Audio and Microphonics. Circuits II. Servomechanisms. Ultrasonics. Materials and Components. Filters I. Television I. Electron Tubes I. Nucleonics. Filters II. Television II. Electron Tubes II. Computers. Network Synthesis. Transistors. Instrumentation I. Microwaves. Engineering Management. Instrumentation II. Communication. Appendices.

How to Use Meters. John F. Rider. New York, John F. Rider Publisher, Inc., 1954. 156 pp., illus., diagrs., figs. $2.40.

How to Use Meters is a practical book. The theoretical aspects of current- and voltage-measuring devices are held to a minimum in these pages. Here and there some reference is made to theory, but by and large the main theme is expressed by the title of the book. The purpose is to serve the needs of the electronic maintenance technician, the technician in industrial and electronic laboratories, the radio amateur, the experimenter in electronics, and the men and women who are studying electronics in commercial academic, and military schools.

FLIGHT SAFETY

Ground Safety in Aviation Operations. John A. O'Donnell and John V. Grimaldi. New York, American Museum of Safety and the Center for Safety Education, Division of General Education, New York University, 1954. 71 pp., diagrs., figs. $1.00.

The purpose of this book is to provide, by means of a clear and concise description of the fundamentals of safe ground operations, accumulated knowledge that can, if properly applied, contribute in a large manner to the protection of airline and airport personnel and also of the public served by air lines. Safety supervisors, maintenance crews, cargo handlers, and all other ground personnel will find in this book much of value to help them in their work. Flight personnel, who are concerned with safety on the ground as well as aloft, will also find it of great interest. The authors are associated respectively with American Airlines, Inc., and the Association of Casualty and Surety Companies. Captain Edward V. Rickenbacker, Chairman of the Board, Eastern Air Lines, Inc., has written the introduction.

HUMAN ENGINEERING

Human Engineering Guide for Equipment Designers. Wesley E. Woodson. Berkeley, University of California Press, 1954. 246 pp., illus., diagrs., figs. $3.50.

This guide is intended to aid the designer in making optimum decisions wherever human factors are involved in man-operated equipment by providing a central source for information about the human operator, by pointing up the relative importance of variables that make a difference, and by indicating solutions for typical design problems. The purpose of this introductory study is twofold: to clarify the nature of human engineering in its application to equipment design problems and to indicate the most expedient method for utilizing the guide material. The author is associated with the Human Engineering Branch, Human Factors Division, U.S. Naval Electronics Laboratory, San Diego.

Contents: Design of Equipment and Workspace. Vision. Audition. Body Measurement. Other Factors. Bibliography for Design Applications. Suggested Reference Library. Subject Index.

For information on IAS Library Service Facilities, see page 91

Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

INSTRUMENTS

The Design and Use of Instruments and Accurate Mechanism. T. N. Whitehead. New York, Dover Publications, Inc., 1954. 283 pp., diagrs., figs. Cloth, $3.95; Paper, $1.95.

Although the principles set down in this book are primarily for the guidance of the instrument designer, most of them are equally applicable to mechanism as a whole. The most important function of the principles is to show the design-engineer how to combine the necessary mathematical abstractions with independent observation of the actual facts.

Contents: Instruments and Their Parts. Systematic Errors (False Elements). Probability as Applied to Error. Short Period Errors (Disturbed Elements). Erratic Errors (Incomplete Elements). Precision: Kinematic Design. Precision: Semikinematic Design. Stiffness, Isolation and Protection of the Elements. Accuracy. The Planning of an Instrument. The Human Factor. Index.

MATHEMATICS

Calculus of Variations by Parallel Displacement. W. S. Kimball. London, Butterworths Scientific Publications; New York, British Book Centre, Inc., 1952. 543 pp., figs. $9.80.

This book treats the subject of the calculus of variations as that branch of advanced calculus which deals with line integrals and their rates of change, using the fundamental identities as its framework. Emphasis is on problem applications, and more than 200 are listed.

Contents: The Fundamental Identities of the Calculus of Variations and Their Significance. The Vector Integrand and its Components for Any Line Integral in a Plane. Dependent Line Integrals and the *E*-Function. Basic Equations for Solving all Maximum and Minimum Problems in the Calculus of Variations. Operational Technique and Applications. Mechanics and the Calculus of Variations. Hilbert Integrals. Area Derivatives and the Legendre and Weierstrass Criteria for Extrema in the Calculus of Variations. The Envelope Theorem, Conjugate Points and Jacobi's Necessary Condition. The Brachistochrone. Newton's Problem. Restricted Corner Conditions, the Vanishing *E*-Function and Variable End-points in the Calculus of Variations. Unrestricted Corner Conditions and the Weierstrass-Erdmann Corner Condition. Minimum Surfaces of Revolution. The Series of Derived Hilbert Integrals in the Role of Families of Level

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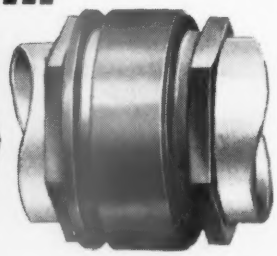

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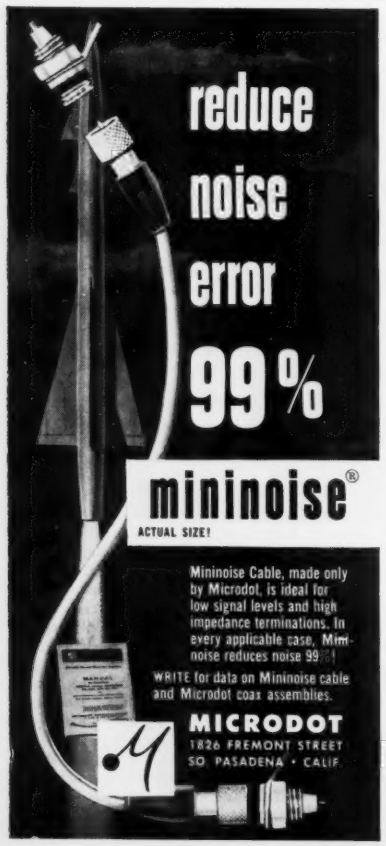
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POWER PLANTS

Aircraft Engines of the World, 1954. Paul H. Wilkinson. New York 14, 225 Varick Street, Paul H. Wilkinson, 1954. 320 pp., illus., diagrs., figs. $12.

This edition presents the latest information about jet engines and reciprocating engines from all over the world, in standardized page form. There are 84 new illustrations, and the contents have been brought up to date as of May, 1954. A new feature has been added—an Accessories and Equipment Section that describes the latest activities of many important manufacturers in this field. The Jet Engines and Gas Turbines Section now includes standardized data of 77 power plants. The Introduction reviews the activities of more than 30 jet-engine manufacturers in eleven countries. Tabulations of 47 turbojets, 18 turbojets with afterburners, and 14 turboprops are included for comparative purposes. Complete descriptions of 15 new engines include the Japanese Nihon JO-1. New specialized power plants, such as the Boeing 502 shaft drive unit, the Continental 140 air compressor, and Marquardt supersonic ram-jets, are also described. All other engine specifications have been completely revised. There are 30 new photographs in this section, including the Pratt & Whitney J57 with afterburner. The Reciprocating Engines Section occupies 106 pages and includes eight new engines. There is also a complete specification of the latest Napier Nomad compounded diesel, now in limited production. The Accessories and Equipment Section, which follows the engine section, contains individualized write-ups covering 23 leading manufacturers in the United States and Great Britain. Each write-up mentions the latest products of the company and illustrates one of them. The Aircraft and Their Engines Section contains seven tabulations including military jet aircraft, jet planes, and helicopters. Data of 24 jet-engined air liners—in production and projected—are included.

Convegno di Studio sulla Propulsione a Reazione. Milano, 21 Aprile, 1952 (Convention on Reaction Propulsion Studies). Roma, Consiglio Nazionale delle Ricerche, 1952. 78 pp., diagrs., figs. Lire 800. (In Italian with English Abstracts.)

Contents: General Outlook on the Problems of Jet Propulsion, Modesto Panetti. Influence of Height and Speed on the Efficiency of Jet Propelled Aircraft, Gaspare Santangelo. Logarithmic Diagram Summing up the Characteristics of the Use of a Turboreactor, Attilio Lausetti. High Efficiency Axial Compressors, Gianni Jarre. Problems of Experimentation on Jet-Propulsion Aircraft Models, Carlo Mortarino. The Present State of Small Power Turbojet Techniques, Piero Crocchi. Short Notes on New Test Equipment for Fiat Jet Engines, Salvatore Majorca.

ROTATING WING AIRCRAFT

Cavalry of the Sky; The Story of U.S. Marine Combat Helicopters. Lynn Montross. New York, Harper & Brothers, 1954. 270 pp., illus., diagrs., figs. $3.00.

Cavalry of the Sky tells the story, from official records, of the development of helicopters in the U.S. Marine Corps from the concepts of 1947 to the new large transport helicopters of 1954. It is also a detailed history of the tactical use of helicopters in the Korean conflict. It is amply illustrated with 32 pages of photographs and 12 pages of line drawings and maps. Also included are a glossary of terms and abbreviations, a list of USMC helicopter units and commanding officers, a bibliography, and an index of places, names, and aircraft.

STRUCTURES

Designing by Photoelasticity. R. B. Heywood. London, Chapman & Hall, Ltd., 1952. 414 pp., illus., diagrs., figs. 65*s*.

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This book draws attention to the photoelastic method of stress analysis, which by recent simplifications in technique has progressed from the field of pure research to that of applied research. The method requires an engineer familiar with the design aspect of the problem rather than a physicist highly skilled in photoelastic techniques. The remarkable "freezing" method of stress analysis is described, which permits the analysis of complicated three-dimensional parts such as crankshafts. Stress concentration factors are of considerable importance to the modern designer, and values of these factors scattered throughout an extensive literature are correlated and presented in a form convenient for reference purposes. Dr. Heywood has had much experience with designing by photoelasticity and is now Principal Scientific Officer, Structures Department, Royal Aircraft Establishment, Farnborough. The author has included a classified bibliography of 826 titles which adds to the book's reference value.

Contents: Behaviour of Light in Polariscope. Photoelastic Materials. Models: Their Preparation and Testing. Model Stresses Applied to Prototypes. Frozen Stress Technique for Three-Dimensional Analysis. Stress Concentration in Particular Notches. Stress Concentration in Screw Threads, Bolts and Nuts. Stress Concentration at Holes. Improvement of Designs. The Application of Stress Concentration Factors. References. Name Index. Subject Index.

Airplane Structures. Alfred S. Niles and Joseph S. Newell. 4th Ed. New York, John Wiley & Sons, Inc., 1954. 607 pp., illus., diagrs., figs. $7.75.

The fourth edition of *Airplane Structures*, like its predecessors, is designed to provide concrete knowledge of the principles of stress analysis. These principles are presented in sufficient detail to enable the reader to understand thoroughly the theoretical considerations involved and to become familiar with efficient procedures for their application. Almost completely rewritten, the book reflects recent developments in the field. It is geared to help the reader make effective use of the more advanced literature, solve conventional problems by standard methods, and develop procedures of his own which are suitable to unconventional problems. The volume includes many new features, such as a new approach to the analysis of riveted joints, a completely new chapter on the physical properties of structural materials, expanded treatment of shells and tension-field beams, new nomograms for use in practical design, and new illustrations to accompany new material. For this edition a new and comprehensive set of problems, graded in difficulty, has been prepared. Solutions for many of these problems are provided.

WIND TUNNELS

Introduction to Wind Tunnel Testing. R. F. Robinson and D. H. Novak. 2nd Ed. West Lafayette, Ind., University Book Store, 1952. 87 pp., diagrs., figs. $2.00.

The authors' purpose in writing this manual has been to present a concise introduction to experimental aerodynamics. They have written for the beginning student and have avoided strongly theoretical treatment as well as a handbook style of presentation. Simple derivations of most of the equations attempt to demonstrate the principles involved. High-speed testing has not been included, since it is usually not taught at this level because of its greater complexity and the high cost of text facilities. The book is reproduced by offset from typewritten copy. R. F. Robinson is with the USAF Institute of Technology, and D. H. Novak is Assistant Professor of Aeronautical Engineering, Purdue University.

Contents: Historical Introduction. Wind Tunnel Components. Instrumentation. Wind Tunnel Calibration. Two Dimensional Wind Tunnel Testing. Three Dimensional Testing.

Aeronautical Reviews

(*Continued from page 124*)

Wind Tunnels & Research Facilities

Investigation of a Convergent-Divergent Nozzle in a Supersonic Wind Tunnel. J. J. Ginoux. (*Rev. Universelle des Mines* [Belgium], Apr., 1954, p. 85.) *Engr. Dig.*, Aug., 1954, p. 317. Theoretical and experimental study by the Belgian Aero. Research Bd.

Investigation of Mach Number Changes Obtained by Discharging High-Pressure Pulse Through Wind Tunnel Operating Supersonically. Rudolph C. Haefeli and Harry Bernstein. *U.S., NACA TN 3258*, Aug., 1954. 14 pp.

Some Applications of the Electrolytic Tank to Engineering Design Problems. H. Diggle and E. R. Hartill. (*IEE Measurements Sect. Paper 1627.*) *Proc. IEE Part II*, Aug., 1954, p. 349; Discussion, p. 364. Basic principles and possibilities of this analogue technique for research, including study of fluid-flow problems.

What Goes on in Wind Tunnels. A. E. Knowler. *Shell Av. News*, July, 1954, p. 14. Expression of the results of experimentation in mathematical terms.

Keep Posted on New Aircraft Products and Product Literature

Make it a habit to check the *Aeronautical Engineering Review's* "New Products Section" every month. Located at the end of each issue, it contains a complete review of all recently announced new product developments and product literature of special interest to the aeronautical profession. Handy tear-out postals are included for your convenience in requesting additional information direct from the manufacturers.

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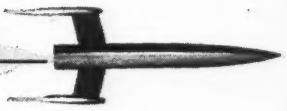

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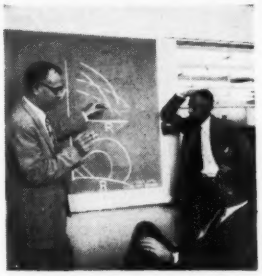

W. W. Lindsay, Jr., Electronics Committee Chairman (left), Sherwood C. Frey, Navy Studies Department Manager (seated), and R. P. Buschmann, Company Studies Department Manager (right), examine relationships between plane and radar performance.

Operations Research and Systems Analysis

Dr. L. Alaoglu, Mathematics Committee Chairman (left), and Ed Quilter, Capt. U.S.N., Ret., Consultant (right), discuss alternate overseas transport routes between the U.S. and Europe.

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Jim Hong, Aerodynamics Division head, discusses results of high speed wind tunnel research on drag of straight and delta wing plan forms with Richard Heppe, Aerodynamics Department head (standing), and Aerodynamicist Ronald Richmond (seated right).

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ANALYSIS OF ADVERTISING CONTENT
(First 6 Months—1954)

PRODUCT ADVERTISED	PERCENT TOTAL ADS
Airborne Mechanical Parts	25.5%
Airborne Electrical/Electronics	14.1%
Aircraft Engines & Parts	13.1%
Engineering Personnel Ads	10.4%
Research/Test Equipment	8.4%
Aircraft Materials	8.1%
Hydraulic/Pneumatic/Oxygen Systems	7.8%
Flight Instruments	6.1%
Airplanes	4.2%
Airline/Airport Equipment	1.3%
Production Tools & Equipment	0.5%
Miscellaneous	0.5%
Total Ads Carried	100.0%

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12 Full Page Ads (at $240)	$2.880
12 Two-Third Page Ads (at $190)	2.280
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AIRCRAFT MATERIALS & PROCESSES

Custom-Compounded Silicone Rubber. Descriptive brochure. **Acushnet Process Co., New Bedford 2, Mass.**

"Alloy Designation System for Wrought Aluminum. 8-page booklet lists new designations effective October 1, 1954. **The Aluminum Assn., 420 Lexington Ave., New York 17, N.Y.**

Colfix Jet Seal Coating for Airport Runways. Descriptive 4-page bulletin. **American Bitumuls & Asphalt Co., 200 Bush St., San Francisco 4, Calif.**

Aluminum Protective Process. 4-page folder describes "Alodine" No. 1200. **American Chemical Paint Co., Ambler, Pa.**

Beryllium Copper Strip. 4-page technical data sheet No. 300. **Industrial Div., American Silver Co., Inc., 36-07 Prince St., Flushing 54, N.Y.**

A-4000 Silicone Rubber Adhesive. Sets up without pressure in 24 hours at room temperature and may be used to bond silicone rubber to itself or to aluminum, magnesium, stainless steel, butyl, or saran rubber. **Dow Corning Corp., Midland, Mich.**

Jet Alloy. For turbine wheel buckets and other applications; this alloy is capable of withstanding higher temperatures than any wrought alloy. **General Electric Co., Carboloy Dept., Detroit 32, Mich.**

Expandable Polystyrene Foam Material. Descriptive 24-page bulletin No. C-4-204. **Koppers Co., Inc., Chemical Div., Koppers Bldg., Pittsburgh 19, Pa.**

Frozen Mercury Process for Producing Precision Castings. Descriptive 8-page booklet, "The Mercast Process." **Mercast Corp., 295 Madison Ave., New York 17, N.Y.**

Metal Powders. Descriptive 4-page bulletin No. 1. **National Radiator Co., Plastic Metals Div., Johnstown, Pa.**

Stainless Steel Alloy Spring Wire. For applications where high spring loadings are required under corrosive conditions and where compactness of components is essential. **National-Standard Co., Niles, Mich.**

"Magseal" Impregnating Process. Increases the corrosion resistance of magnesium over 300 per cent. **Nu-Line Plastic Impregnation Co., Inc., 3457 E. 15th St., Los Angeles, Calif.**

Weldable High-Strength Titanium-Base Alloy Sheet. "Rem-Cru A-110AT" contains 5 per cent aluminum and 2½ per cent tin. **Rem-Cru Titanium, Inc., Midland, Mich.**

AIRCRAFT PARTS & EQUIPMENT

Franklin 0-425-2 Reciprocating Engine. Designed to provide helicopters with increased sea level and altitude performance. **Aircooled Motors, Inc., Syracuse, N.Y.**

Lightweight Lightning Arrester. For protection of communications gear on multiengined or jet aircraft. **Airtron, Inc., Linden, N.J.**

Remote Adjustable Thermostat. Bulletin F 4340-1 describes temperature control for aircraft combustion heaters. **Barber-Colman Co., Aircraft Controls Div., 1200 Rock St., Rockford, Ill.**

Ball-Bearing Swivel Joints. Descriptive 32-page catalog No. G-4. **Chiksan Co., Brea, Calif.**

Priority Valve for Pneumatic Systems. Increases effectiveness of pneumatic system moisture separator. **The Cornelius Co., 550 39th Ave. N.E., Minneapolis 21, Minn.**

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25-Watt Miniature Motor. Designed for use as a driving element in low- or high-speed linear or rotary-actuator applications. Descriptive leaflet No. SR-43. **Dalmotor Co., 1303 Clay St., Santa Clara, Calif.**

Type SC-23 Constant-Speed Motor. Maintains a constant governed speed of 7,100 r.p.m. ± 1.0 per cent from 24 to 30 volts d.c., and with load variations of ±30 per cent. **Dalmotor Co., 1303 Clay St., Santa Clara, Calif.**

Miniature Magnetic Clutch & Brake. For application in computers and mechanisms which require a high order of clutching and braking accuracy. **Ford Instrument Co. Div., The Sperry Corp., 31-10 Thomson Ave., Long Island City 1, N.Y.**

Precision Cams. 4-page bulletin describes units for computing and motion applications **Ford Instrument Co. Div., The Sperry Corp., 31-10 Thomson Ave., Long Island City 1, N.Y.**

Ball Piston Constant Speed Hydraulic Drive. Most of the important functions are enclosed in one casing. **General Electric Co., Schenectady 5, N.Y.**

Model 3038-D Aircraft Seat. Features folding legs and backs for minimum storage-space requirements. **Hardman Tool & Engineering Co., P.O. Box 13825, 1845 S. Bundy Dr., Los Angeles 25, Calif.**

Three-Blade Feathering Propeller. For use on light twin-engined aircraft. **Hartzell Propeller Co., Piqua, Ohio.**

Stainless Steel Fittings. Produced by a new "centrifugal casting" method. **Industrial Research Laboratories, 961 E. Slauson Ave., Los Angeles 11, Calif.**

Lightweight Hex Nut. Designed to effect weight-savings up to 3/8. **The Kaynar Co., Kaylock Div., 820 E. 16th St., Los Angeles, Calif.**

Instrument Practice Hood. This plexiglas hood is suspended from the ceiling of an airplane and can be put up or taken down in less than a minute during routine flight. **Line-O-Site Co., Baxter Springs, Kan.**

Quick Opening Flush Latches. For access doors, cowlings, and similar applications in high-speed aircraft. **Modern Aviation Co., 2812 S. Main St., Los Angeles 7, Calif.**

Lightweight Pressure Regulator. Weighs 0.93 lb. and has a capacity of 19 lbs. per min. airflow at 70°F., at a 5,000-ft. altitude. **Pacific Airmotive Corp., 2940 N. Hollywood Way, Burbank, Calif.**

External Fuel Tank Ejection System. A simplified jettisonable fuel tank and an ejector pylon containing an explosive charge enable safe, positive ejection at any speed or possible flight attitude. **Pastushin Aviation Corp., 6901 Melrose Ave., Los Angeles 38, Calif.**

Machined Aircraft & Engine Parts. 24-page company brochure describes gears, sprockets, shafts, bronze castings, and similar parts. **Penn Machine Co., Johnstown, Pa.**

R-500 Plastic Fuel Hose. Will handle hydrogen peroxide and white fuming nitric acid in rocket engines. **Resistoflex Corp., Belleville, N.J.**

Aircraft Hose & Hose Assemblies. For use in fuel, oil, and hydraulic systems; 16-page descriptive catalog. **Resistoflex Corp., Belleville, N.J.**

SL 1029 Overheat Switch Insulator Self-Locking Nut. For use in high-temperature applications. **Shur-Lok Corp., 9010 Bellanca Ave., Los Angeles 45, Calif.**

Air Flight Safety Equipment. Assembly includes a newly designed flying suit, parachute, and harness. **Switlik Parachute Co., Trenton, N.J.**

Air-borne Hydraulic Winch System. Descriptive 4-page catalog No. A-5225. **Vickers, Inc., 1400 Oakman Blvd., Detroit 32, Mich.**

Lightweight Hydraulic Pump. This variable displacement piston-type unit features a cast steel yoke and magnesium-zirconium alloy housing. **Vickers, Inc., 1400 Oakman Blvd., Detroit 32, Mich.**

Series 5139 Retaining Ring. For applications in which an easily assembled, positive-locking fastener is required. **Waldes Kohinoor, Inc., 47-16 Austel Pl., Long Island City 1, N.Y.**

Remote Actuated Coupling for Missiles. Used as the connection between the missile and the vital electrical cable that runs to the missile. **E. B. Wiggins Oil Tool Co., 3424 E. Olympic Blvd., Los Angeles 23, Calif.**

ELECTRONIC & ELECTRICAL EQUIPMENT

Compression Connectors in Electrical Manufacturing. A series of charts to facilitate selection and identification of "Burndy Hydent" connectors. **Burndy Engrg. Co., Inc., Norwalk, Conn.**

Melamine Fuse Block, Type F3H-M. These units have high physical and dielectric strength that provides excellent resistance to power arcing. **Burndy Engrg. Co., Inc., Norwalk, Conn.**

Electrical Disconnect Panels. Descriptive 20-page Panelok bulletin No. YHS54. **Burndy Engrg. Co., Inc., Norwalk, Conn.**

Miniature Plugs & Receptacles. Designed for the particular demands of the computer field. Bulletin No. SR-KM1. **Cannon Electric Co., 3209 Humboldt St., Los Angeles 31, Calif.**

Aircraft Buffet Connectors. Descriptive 8-page bulletin No. BU-1. **Cannon Electric Co., 3209 Humboldt St., Los Angeles 31, Calif.**

Model 19 12-Channel Electronic Switch. Displays 12 separate signals on a conventional single-channel cathode-ray tube. **Century Geophysical Corp., 1333 N. Utica, Tulsa, Okla.**

Miniature Capacitor. Designed for use in aircraft radio and radar equipment. **Condenser Products Co., 140 Hamilton St., New Haven, Conn.**

Permanent-Magnet & Wound-Field D.C., A.C. & Sine Wave Generators. Descriptive 24-page catalog No. E1-1A. **Electric Indicator Co., Inc., Springdale, Conn.**

A.C. Rate Generators & Servo Packages. Designed for any use that requires a high degree of accuracy in the linear translation of rotational motion into voltage. **Ford Instrument Co., Dept. RGB, 31-10 Thomson Ave., Long Island City 1, N.Y.**

Hermetically Sealed Adjustable Thermostat. For direct control of heaters and for temperature alarm or cut-off service. **G-V Controls, Inc., 28 Hollywood Plaza, East Orange, N.J.**

Electrical Ceramics. Descriptive 4-page folder. **General Ceramics Corp., Keasbey, N.J.**

3 C.M. Pulse Magnetron. Type GL-6527 is designed for operation without pressurization up to 60,000 ft., primarily for use in air-borne radar gunsights. **General Electric Co., Electronics Pk., Syracuse, N.Y.**

10-Turn Miniaturized Potentiometer. For servo or bushing mounting; available in both linear and nonlinear versions. **Helipot Corp., South Pasadena, Calif.**

Germanium Diodes. Descriptive 4-page bulletin No. GD-1A. **International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.**

"MiniTherm" Subminiature Thermal Switch. This chemical-type unit measures $^3/_{16}$ in. in diameter and $^3/_{16}$ in. in length. **MiniTec, 5423 Delaware Ave., Los Angeles 41, Calif.**

Rotary Electrical Equipment. Bulletin No. 254 describes 50 basic types of miniature motors, blowers, and fans. **Mission-Western Engineers, Inc., 132 W. Colorado St., Pasadena 1, Calif.**

Model VOA-2 Omniplexer. Provides low-cost omniconverter attachment for "Narco" Simplexer, 12-channel VHF communications unit. **National Aeronautical Corp., Ambler, Pa.**

Series 100 & 300 D.C. Solenoids. 300 different types of custom solenoids may be assembled from 20 standard parts. **Joseph Pollak Corp., 81 Freeport St., Boston 22, Mass.**

Encapsulated Wire Wound Resistors. Designed to perform under extremes in humidity, altitudes, and corrosive influences. **Resistance Products Co., 714 Race St., Harrisburg, Pa.**

Model K164 Center-of-Gravity Vibration & Shock Mount. This single-stage mounting design affords maximum stability for electronic equipment and permits installation under limited space requirements. **Robinson Aviation, Inc., Teterboro, N.J.**

PRODUCTION & MAINTENANCE EQUIPMENT

"Appton" Air Hammer. An adjustable impact control regulates the force from a gentle nudge, for delicate work, to a smashing blow for brief, heavy applications. **E. V. Nielsen, Inc., 129 Broad St., Stamford, Conn.**

No. 400 Wet Surfaces Ink. This ink can be applied directly to wet surfaces. Bulletin No. 400. **Organic Products Co., Box 428, Irving, Tex.**

Single-Setting Conversion Slide Rule. Bears 64 linear, liquid, energy, and miscellaneous factors on one side, plus a complete trig scale arrangement on the reverse side consisting of A, K, DF-CF, T, S, CI, C-D, and L scales. **Pickett & Eckel, Inc., 1109 S. Fremont St., Alhambra, Calif.**

Automatic Turret Lathes. Descriptive 24-page catalog. **Potter & Johnston Co., Pawtucket, R.I.**

RESEARCH & TEST EQUIPMENT

"Tempcal Tester." Tests accuracy of thermal switches, overheat detectors and wing anti-ice systems, and cylinder head thermocouples. **B & H Instrument Co., Inc., 1009 Norwood, Fort Worth, Tex.**

Wind Sensing Unit. Measures air currents encountered in aircraft research. **Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pa.**

Model 168 Streak Camera. For the synchronized recording of position-versus-time data. **Beckman & Whitley, Inc., 920 San Carlos Ave., San Carlos, Calif.**

Prefabricated Temperature-Humidity Test Chamber. Units feature expandability; after installation, the chamber can be lengthened by the addition

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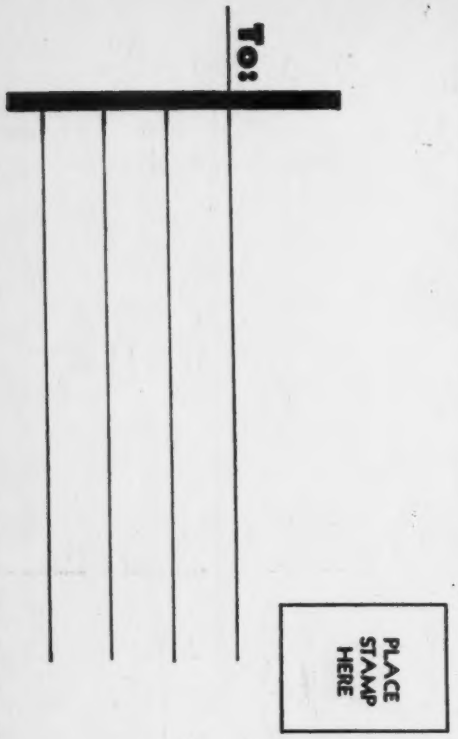

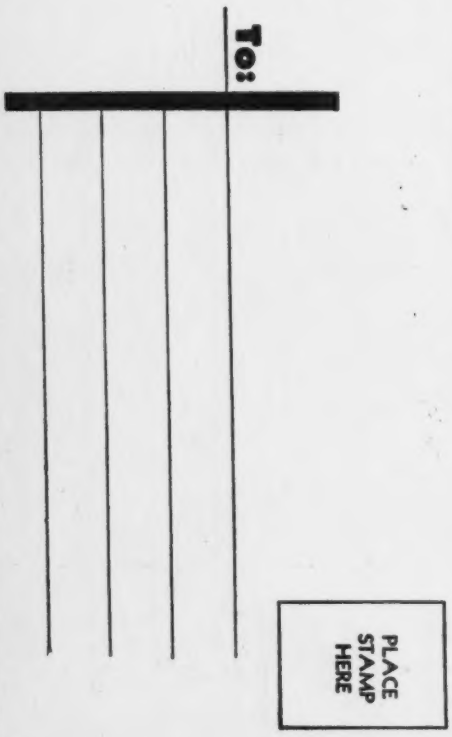

of any required number of sections. **Bowser Technical Refrigeration, Terryville, Conn.**

Model BL-520 Universal Amplifier. Measures and records on a direct writing oscillograph a wide range of physical phenomena: strain, force, pressure, temperature, etc. **Brush Electronics Co., Dept. RT-4, 3405 Perkins Ave., Cleveland 14, Ohio.**

Model BL-530 Dual Channel D.C. Amplifier. Accepts both single-ended and differential signals with a 50-millivolt sensitivity and provides for accurate calibration of the recorded signals. **Brush Electronics Co., Dept. RT-4, 3405 Perkins Ave., Cleveland 14, Ohio.**

Automatic Wave Analyzer. Descriptive 9-page bulletin No. 54-C. **The Davies Laboratories, Inc., 4705 Queensbury Rd., Riverdale, Md.**

D.C. Indicating Amplifier, Type 2HLA-3. Descriptive 2-page bulletin 1A. **Doelcam Corp., Soldiers Field Rd., Boston 35, Mass.**

Model 2101 Force Gage. The extended frequency range and large output permit new dynamic tests of servo systems, vibration-force generators, wind-tunnel balances, structures, etc. **Endevco Corp., 689 S. Fair Oaks Ave., Pasadena 2, Calif.**

Test Stands. For testing the performance of a broad range of electromechanical equipment under rated loads. **Grand Rapids Div., Lear, Inc., Grand Rapids, Mich.**

"Silence Service for Industry." 32-page booklet describes soundproofing materials and units. **Industrial Sound Control, Inc., 45 Granby St., Hartford, Conn.**

"Sound-Asorb" Helmet. For use in engine test cells, around run-ups, or wherever the ambient noise level approaches or surpasses the threshold of pain. **Bill Jack Scientific Instrument Co., P.O. Box C-26, Solana Beach, Calif.**

3 In 1 Hand Tachometers. Descriptive bulletin No. 103. **Metron Instrument Co., 432 Lincoln St., Denver 3, Colo.**

"CR-1" Cathode-Ray Recording Oscillograph. Provides continuous, time-synchronized records of up to 16 separate phenomena at frequencies as great as 50,000 c.p.s. **Wm. Miller Instruments, Inc., 325 N. Halstead Ave., Pasadena 8, Calif.**

High Temperature Accelerometer. Operates at temperatures from −65° to 550°F. **Pacific Scientific Co., 1430 Grande Vista Ave., Los Angeles 23, Calif.**

Pressure Pickups. This instrument is capable of operation at temperatures up to 6,000°F., in highly corrosive atmospheres, and with the broadest range of measurement parameters. **Photocon Research Products, 421 N. Foothill Blvd., Pasadena 8, Calif.**

Creep Testing Machine. For determining the stress required to rupture specimens as well as the creep properties up to rupture. **Riehle Testing Machines Div., American Machine & Metals, Inc., East Moline, Ill.**

CA-500 Lightweight Mach Number Computer. This 4½-lb. unit provides accuracy of 0.01 Mach for 95 per cent of laboratory test points. **Servomechanisms, Inc., 500 Franklin Ave., Garden City, L.I., N.Y.**

Model TC-2 Temperature Test Chamber. Descriptive 4-page brochure. **Statham Development Corp., 12411 W. Olympic Blvd., Los Angeles 64, Calif.**

Aircraft Engine Temperature Indicator Tester. Designed to test and calibrate either single 12 V, 24 V, or dual 24 V ratiometer-type temperature indicators and single or dual thermocouple temperature indicators. **Telectro Industries Corp., 35-18 37th St., Long Island City 1, N.Y.**

Self-Contained Table-Model Low-Temperature Test Chamber. Produces temperature to −100°F. and will dissipate 1,000 B.t.u. per hr. at −80°F. **Tenney Engineering, Inc., 1090 Springfield Rd., Union, N.J.**

Model S-3 Diaphragm Type Pressure Transducer. This gage operates on the variable reluctance principle and is suitable for use with a variety of recording and telemetering systems. **Ultradyne Engineering Labs., Inc., P. O. Box 8007, Albuquerque, N.M.**

NEW LITERATURE OFFERED BY ADVERTISERS

"Blue Ribbon" Electrical Connectors. Catalog R1. **American Phenolic Corp., Chicago 50, Ill.** *See page 90*

Miniature Lubrication Pump. Aircraft Catalog. **Eastern Industries, Inc., 100 Skiff St., Hamden 14, Conn.** *See page 87*

"Air-Turbine Facility." Brochure. **Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N.J.** *See page 110*

Servo Motors & Components. Descriptive bulletin. **Kearfott Co., Inc., Little Falls, N.J.** *See page 119*

CR-1 Cathode Ray Recording Oscillograph. Descriptive information. **Wm. Miller Instruments Inc., 325 N. Halstead Ave., Pasadena 8, Calif.** *See page 78*

Shear Plate Valves & Aircraft Fuel & Hydraulic Products. Product data. **Parker Aircraft Co., Sect. 802-A, 5827 W. Century Blvd., Los Angeles 45, Calif.** *See page 121*

"High Speed Aerodynamics & Jet Propulsion." Brochure. **Princeton University Press, Dept. A21, Princeton, N.J.** *See page 126*

Aircraft & Power Plant Equipment. Descriptive booklets. **Westinghouse Electric Corp., 3 Gateway Center, P.O. Box 868, Pittsburgh 30, Pa.** *See page 106*